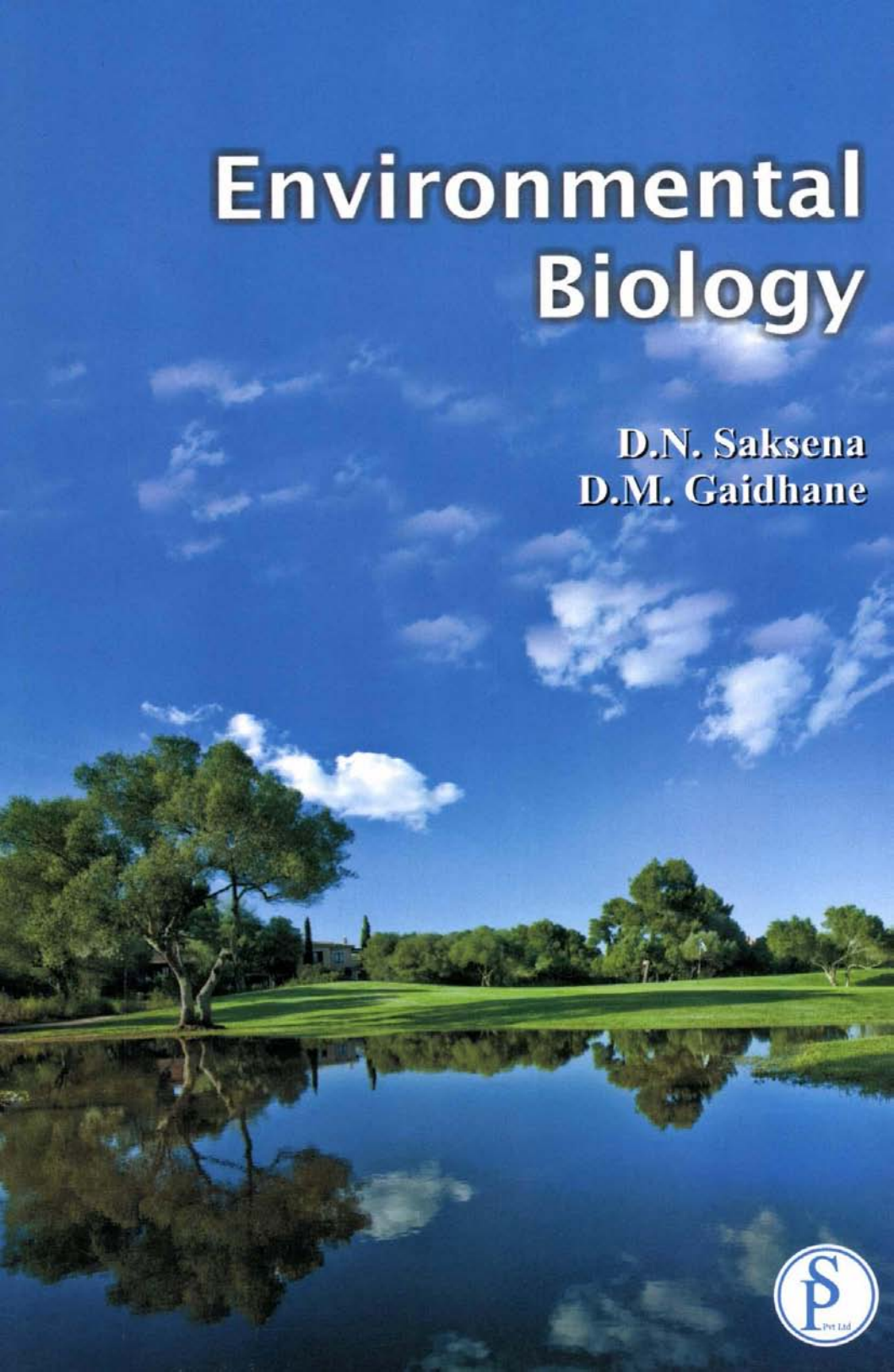
Environmental Biology

D.N. Saksena
D.M. Gaidhane



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To,
Our Parents

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PREFACE

The scope of Environmental Biology has enlarged tremendously during the past few decades. An important development is its orientation to global problems and that the man shares a common earth. Such a concern about environment on global level have led to an attempt towards achieving a true goal of development, especially an environmentally sound and sustainable development. In recent years, spectacular advances have been made in this discipline and also many important developments have occurred. In present days, the ecologists use their knowledge for the benefit of human society. Modeling, systems analysis and futuristic approach have become important aspects of Environmental Biology. All these areas of the study can be treated at different levels by keeping the backgrounds of the student and teacher's in mind.

Environmental Biology is one of the important component of the environmental science and it is concerned with the study of air, land, water and energy system in relation to the system of life. The present book is based on the concept of Environmental Biology, both traditional and modern ways. The text is primarily designed to meet the requirement of students, teachers and whose interest is in Environmental Biology. This book will provide up to date knowledge to the students of Environmental Biology in Colleges and Universities as well as all others, who want to refresh and systematize their knowledge of Environmental Biology. It is hoped that this book will meet the needs of both the students and teachers equally well. We have tried a simple, comprehensible, well illustrated and authentic documented account of different topics in Environmental Biology. The book will provide base for those students who have a background of the knowledge of Environmental Biology, and those who wish to take up subject at the University and College level.

This book prefers a fresh, problem solving treatment of the topic for students requiring the background of biology for the further studies. It starts with the theme of environment followed by its biology that carries through its text and other explanatory matter. The key for the foundation of knowledge is

introduced and developed through the text, and the students are encouraged to integrate their learning to reach the solutions. The book introduces all the facts of the Environmental Biology discipline including, Environment, Biosphere, Biogeochemical cycles, Ecological divisions, Ecological succession, Aquatic and Terrestrial habitats, National Parks and Sanctuaries, Environmental degradation, Greenhouse effect and global warming, Radiation Ecology, Biodiversity, Environmental pollution, Natural resources and their conservation, Wildlife conservation etc. as well as new topics like Environmental Biotechnology, Biopiracy, Eco-terrorism and Intellectual Property Rights. All these topics cover the need and interest of the students and teachers by integrating the Environmental Biology theme throughout the text.

The framework of this book is based on UGC syllabus. So this book is friendly to the students and teachers of the Environmental Biology. In this book, a systematic concept of the Environmental Biology is presented in simple and intellectual manner. Thus, this up-to-date comprehensive text deals with the various facts and dimensions of the Environmental Biology. The text has been written in simple and lucid language to make learning easier. Well labelled figures and tables have been furnished at appropriate places for better understanding and latest developments and new concepts have been included in the book.

We express our heartfelt thanks to various ecologists and authors whose work has been incorporated in the book. We are thankful to Librarians of Central Library of Jiwaji University, Gwalior, M.P., Janta College, Chandrapur, M.S. and Gurunanak College, Ballarpur, District Chandrapur. Thanks are also extended to researchers of Aquatic Biology and Fish Biology Laboratory, School of Studies in Zoology, Jiwaji University, Gwalior, M.P. for their timely co-operation. We are immensely grateful to our family members who have given support to us throughout this work. Finally, we wish to acknowledge our publisher M/s Studium Press (India) Pvt. Ltd. New Delhi, Dr. J.N. Govil, Director and his staff for their constant stimulus and co-operation during the preparation of the book as well as for taking interest in its publication. Suggestions for improvement of the book are always welcome and would be incorporated in future editions.

Gwalior, M.P. **Prof. D.N. Saksena**

5th June, 2010 **Dr. D.M. Gaidhane**

CONTENTS

Preface		vii
1.	Environmental Biology	1
2.	Environment	6
3.	Biosphere	28
4.	Biogeochemical Cycles	52
5.	Population Ecology	69
6.	Ecological Divisions of India	81
7.	Ecological Succession	89
8.	Freshwater Habitats	102
9.	Marinewater Habitats	111
10.	Estuarine Habitats	120
11.	Terrestrial Habitats	125
12.	National Parks and Sanctuaries	136
13.	Environmental Degradation and Pollution	155
14.	Greenhouse Effect and Global Warming	163
15.	Radiation Ecology	170
16.	Urbanization	178
17.	Biodiversity	181
18.	Environmental Pollution	197
19.	Natural Resources and their Conservation	228
20.	Wildlife Conservation	253
21.	Environmental Biotechnology	259
22.	Biopiracy	288
23.	Eco-terrorism	303
24.	Bibliography	310
	Subject Index	313

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1

ENVIRONMENTAL BIOLOGY

The revised approach to the environment, environmental science has developed to tackle the environmental problems. Environmental science is an integrated multi-disciplinary science that can be defined as, the study of air, land, water, energy and life surrounding the man. Environmental biology may, thus be defined as, the study of air, land, water and energy systems in relation to all life. Hence, it is the study of atmosphere, hydrosphere and lithosphere in relation to the biosphere.

The special term for the field of environmental biology is ecology. The word 'ecology' is derived from the two Greek words, 'oikos' meaning 'house' and 'logos' means 'study'. Thus, literally ecology is the study of houses or in more broad sense environments, because ecology is concerned especially with the biology of groups of organisms and with functional processes on the lands, in the oceans and in freshwaters. According to E.P. Odum (1971), environmental biology can be defined as, "the study of the structure and function of nature." It should be thoroughly understood that mankind is a part of nature, since we are using the word nature to include the living world.

Conventionally, environmental biology has been variously defined by different classical and modern ecologists with different viewpoints. Thus, ecology grew and matured

during post-industrilization era with much more responsibilities and concerns into a new multidisciplinary field of environmental science.

SCOPE

The scope of environmental biology has enlarged as a result of widening of the dimension of the environment. It is a multi-disciplinary field borrowing freely from other, often overlapping fields of environmental science. The basic principles of ecology are applied to understanding how organisms manage to survive under an array of combinations of ecological factors of the environment under natural conditions. The scope of environmental biology has been dealt here.

1. The principles of environmental biology provides a background for understanding the fundamental relationship of the natural community and also the sciences dealing with particular environment *viz.*, forest, soil, ocean and inland waters.
2. Many practical applications of this subject are found in agriculture, horticulture, forestry, limnology, oceanography, fisheries, biological surveys, pest control, public health, toxicology, pollution control, conservation etc.
3. By applying certain ecological techniques, ecologists find the causes of desertness. They investigated that these deserts lack certain trace elements like Zinc (Zn), Copper (Cu), and Molybdenum (Mo), so they called them trace element deserts (Anderson and Underwood, 1959). Now they have cured their ecological diseases and have converted them into new rich agricultural lands.
4. There are environmental engineers and environmental geologists who could study the

behaviour of the interior of earth and advise in matters of construction work.

5. There can also be included the role of anthropologists, sociologist and economists who contribute to environmental biology in the changed scenario of development.

SUB-DIVISIONS AND BRANCHES

Environmental biology is divided into two sub-divisions *viz.*, autecology and synecology. Autecology deals with the ecological study of one species of organism. Autecologist may study the life history, population dynamics, behaviour, home range and so on of a single species. Synecology deals with the ecological studies of communities or entire ecosystems. A synecologist might study desert or caves or tropical forests. He may be interested in describing the overall energy and material flow through the system. Thus, autecology and synecology are inter-related, where the synecologist is painting with broad brush the outline of the picture and autecologist is stroking in the finer details.

Besides, there are following specialized branches of environmental biology. Only selected branches are enumerated here.

1. **Habitat ecology:** It deals with study of an habitat. It may be terrestrial or aquatic habitat. The aquatic habitats are freshwater and marine.
2. **Community ecology:** The community ecology deals with the study of the local distribution of animals in various habitats.
3. **Population ecology:** This branch of environmental biology is concerned with the growth, structure and regulation of population of organisms.
4. **Evolutionary ecology:** It deals with the problems of the niche segregation and speciation.

5. **Taxonomic ecology:** It is the study of different taxonomic groups of living organisms in relation to environment.
6. **Applied ecology:** The applied ecology deals with the applications of ecological concepts to the human needs. It includes wildlife management, forestry, conservation, insects control, aquaculture, agriculture, horticulture, animal husbandry, land use and pollution ecology.
7. **Production ecology:** The production ecology is concerned with the gross and net production of different ecosystems like freshwater, marine, agriculture, horticulture etc.
8. **Radiation ecology:** It deals with the study of gross effects of radiation and radioactive substances on the environment and living organisms.
9. **Ethology:** Ethology is the study of animal behaviour under natural conditions.
10. **Systems ecology:** It is the modern branch of ecology which is particularly concerned with the analysis and understanding the structure and function of the ecosystem through the use of applied mathematics, mathematical models, computer applications etc.
11. **Pedoecology:** It is the branch of terrestrial ecology and deals with the study of soils, particularly acidity alkalinity, humus contents, mineral contents, soil type etc.and their influence on the organisms.
12. **Space ecology:** It is a modern sub-division of ecology which is concerned with the development of partially or completely regenerating ecosystems for supporting the life of man during long space flights.

QUESTIONS

1. Define Environmental Biology and discuss its scope.
2. Give an account of various branches of Environmental Biology.

3. Write short notes on:
   A. Scope of Environmental Biology
   B. Sub-divisions of Environmental Biology
   C. Space ecology
   D. Applied ecology
   E. Pedoecology

2

ENVIRONMENT

Each and every living organism has its specific surroundings, medium or environment to which it continuously interacts and remains fully adapted. Thus, we can define environment as the sum total of physical and biotic conditions influencing the responses of organisms. There are two basic components of the environment:abiotic component and biotic component.

ABIOTIC COMPONENTS

The abiotic components are the physical or non-living components of nature which includes the medium in which the organisms live and the climate which influences them. For living organisms like plants and animals, four different types of media are available. These are soil, water, air and bodies of other organisms. These are the components of 3 major sub-divisions of the biosphere including lithosphere, hydrosphere and atmosphere respectively. These media are not completely isolated from each other. However, some of the atmospheric gases are present in all natural waters and some moisture is present almost everywhere in the atmosphere.

1. **Soil:** It is the uppermost stratum of the earth, which contains organic matter and is capable for nourishing the vegetation and inhabiting soil

micro and macro-organisms.

2. **Water:** It is an an important medium for aquatic plants and animals. Water plays an important role in respiration and also helps the body in its metabolism.
3. **Air:** It is present all around the earth in the gaseous form. Although it is a mixture of gases, yet nitrogen and oxygen are present in 78 parts and 21 parts respectively. The remainings one part contains Carbon dioxide (CO_2), Ozone (O_3), Neon (Ne), Argon (Ar) etc. Other constituents like organic matter, dust, micro-organisms, various salts, water vapours etc. are also present. The percentage of these substances is depending upon time and place and have considerable effect on climate, weather, radiation and comfort.
4. **Bodies of organisms:** Certain organisms are found in the body of other animals and they live as parasites. The parasites fulfil their requirements of oxygen and nutrition from internal environment of the host and protect themselves from digestive and other juices. There is no or very little fluctuation in such an environment.

BIOTIC COMPONENT

The biotic component or living organisms include plants, animals and micro organisms. The biotic component can be divided on functional basis into 4 major groups as follows:

1. **Primary producers:** These are chlorophyll bearing organisms and other organisms who are able to synthesize food material themselves.
2. **Herbivores:** The relationship among biotic components may be explained by two popular

phenomenon, *viz.*, intra-specific relationship and inter-specific relationship.

The intra-specific relationship denotes relationship between the members of the same species while the inter-specific relationship shows the relationship between the members of different species.The intra-specific relationship is governed by reproduction, assistance, competition and definite hospitality while inter-specific relationship is governed by the competition for food, prey-predator relation, host-parasite relationship, commensalism, symbiosis and slavery.

I. Intra-specific relationship

1. **Reproduction:** Reproduction affects the intra-specific relationship during sexual or asexual reproduction. Number of individuals may increase, if the rate of reproduction is high. It will results into over production and lead to competition or struggle for food and space.
2. **Assistance:** It means the parental care or the protection given by the parents to their young ones.
3. **Competition:** It results from the over production of offsprings and limited food and shelter.
4. **Definite hostility:** It involves struggle over territorial limits and in the selection of mates.

The competition amongst the members of two different species brings resource competition when they utilize common resources or interference competition where the members of 2 species seek a resource and harm one another in the process. According to the Darwin's theory of natural selection, whenever there is rapid reproduction and limited supply of food, there is always struggle for existence and survival of the fittest.

II. Interspecific relationship

1. **Prey-predator relationship:** It denotes the feeding of one animal over the other. The animal which feeds is the predator and which is eaten is called as prey. The predator can survive only when the prey is available. The prey cannot survive, if the predators are more in number.
2. **Host-parasite relationship:** It may be partial or complete that means a parasite may depend on its host partly or completely.
3. **Commensalism:** It is the phenomenon in which the two individuals lie in close relationship with each other but none is dependent on the other.
4. **Symbiosis:** It is also a close physiological relationship that exists between the members of different species which completely depend on each other.
5. **Slavery:** Slavery means to make the slaves. When certain animal capture the other animals make them slaves and utilize their services. Such phenomenon is called as slavery.

Atmosphere

Major zones and importance

The multilayered gaseous envelope surrounding the planet earth is referred as atmosphere. The atmosphere remains in contact with all the major types of environment of earth interacting with them and greatly affecting their ability to support the life. It filters sunlight reaching on the earth affects climate and is a reservoir of several elements essential for life. Smith (1974) studied the zones of atmosphere. According to him, the atmosphere surrounding the earth consists of a series of following layers or zones *viz.*, 1. Troposphere, 2. Stratosphere, 3. Mesosphere, 4. Heterosphere and 5. Exosphere (Fig. 2.1).

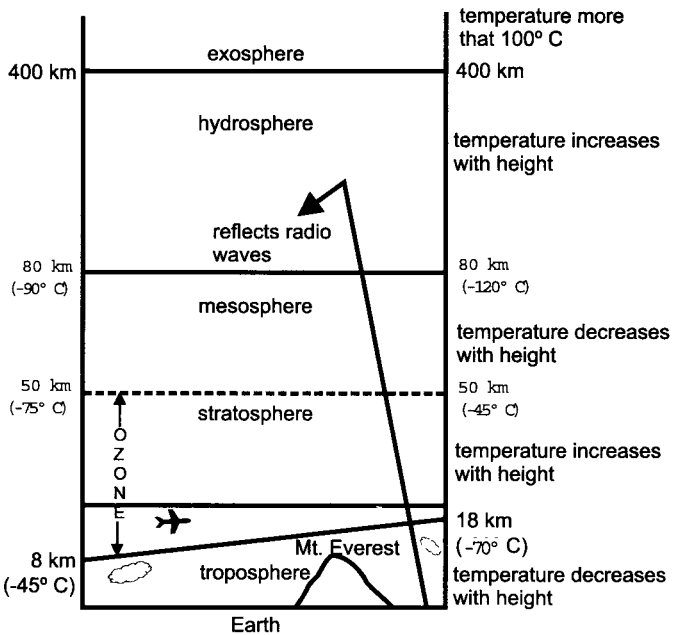


Fig. 2.1: Major zones of atmosphere

1. **Troposphere:** It is the lowest region of atmosphere which hangs at 8 km over the earth at the poles and nearly 18 km over the earth at the equator. This zone, subject to differential heating temperature, inversion and conversion currents is called troposphere. Temperature drops rapidly from 30° to -70°C in the zone. Troposphere is the region of strong air movements and cloud formation. Man along with other living organisms lives in the troposphere.
2. **Stratosphere:** It is 2nd layer of the atmosphere. It is 50 km away from the earth having a fairly constant temperature at - 75°C to - 45°C in its outer region which increases upto 300°C at its lower boundary. Within the stratosphere, ozone (O_3) accumulates sufficiently to produce a well marked ozone layer called 'ozonosphere' which extend about 13 to 23 km above the sea level. In ozonosphere, the sunlight

ionizes oxygen to ozone by photochemical dissociation. The ozonosphere absorbs solar ultraviolet radiation from the sun and saves the earth away from the harmful effects of ultraviolet radiation.

3. **Mesosphere:** It is 3rd layer of atmosphere which is 80 km from the surface of earth. This is the region of cold temperature (-90° to -120°C). The temperature of the mesosphere, however, gradually increases.
4. **Heterosphere:** It is the 4th layer of the atmosphere. In heterosphere, oxygen and nitric oxide occur in ionized state and their ionization is caused by the ultraviolet radiation. The lowest sub-region of heterosphere is called thermosphere. It is 400 km away from the earth and contains mixture of nitrogen (N_2) and oxygen (O_2) in the proportion of 1:1. Further, in this zone the temperature decreases as the distance from sun increases.
5. **Exosphere:** It is the outer fringe of atmosphere which extends about 20,000 km from the earth. The dominant element in this zone is hydrogen and its temperature ranges from 200 to 10,000°C. The higher temperature is due to solar energy or radiant energy of sun. The lower part of exosphere contains abundance of helium besides hydrogen and therefore, is also called 'Helium zone'.

Importance of atmosphere

The role of atmosphere in the maintenance of the biosphere is great and is accomplished as follows:

1. Atmosphere regulates the temperature of the earth crust. The presence of gases capable of absorbing long wavelength radiations and is responsible for maintaining the temperature under which life activities are possible. For instance, moon has no atmosphere. At equator, the surface temperature

increases to 101°C in day time but during night, it falls to -180°C. No life can survive at these extreme temperatures.

2. The temperature and pressure determine precipitation which in turn regulates the abundance and composition of biotic communities on the earth surface.
3. The atmosphere protects the earth surface from the ultra-violet rays originated from the sunlight. These rays severely damage the terrestrial life on the earth.
4. Atmosphere is effective medium for the transfer and dissemination of gaseous wastes.
5. Pollutants in the atmosphere are removed by more affective mechanism than operating on land or in water. The entire load of pollutants is brought down with snow, dew or rain which clean the atmosphere.

Hydrosphere

More than three-fourth of the earth surface *i.e.*, 71% is covered by hydrosphere. The main component of which is water. Water is one of the most unusual natural compound found on the earth and it is also one of the most important constituent of biosphere. Life began on the earth in the sea. Water is also essential for the maintenance of life and also serves as the medium for several ecosystems. Water occur in three forms *viz.*, solid (ice), liquid (water) and gaseous (vapour) forms. Water may be freshwater or marine and thus, it forms two different types of aquatic environments *viz.*, freshwater environment and marine environment.

I. Global distribution of water

Of the total estimated water on the earth and its atmosphere, only about 5% is actually or potentially free

and is in circulation, remaining 95% of the earth's water is bound in the lithosphere and in the sedimentary rocks. Freshwater amounts to only about 3% of the total supply and three-quarters of it is bound up in the polar ice caps and glaciers. Water is present in three forms in nature: i. atmospheric moisture, ii. precipitation or rainfall, and iii. soil water.

i. **Atmospheric moisture:** It occurs in the form of humidity, fog or cloud. Clouds are formed due to the movement of air upward from land surface towards cooler sides of the atmosphere, whereas, fog is caused due to the cooling of air at or near the land surface and is generally continuous from the surface upwards.
ii. **Precipitation or rainfall:** It is the chief source of the soil moisture. Precipitation affects plants as snow, hail and sleet. Hail cause damage to aerial parts of the plants, whereas, snow may or may not harm the plants.
iii. **Soil water:** It forms the chief source of water for plants and comes on the earth as rain. Some of the rainwater evaporates in the atmosphere before it reaches the ground and thus it depicts the relative humidity, which is invisible vapour of the air. During heavy and long period of rainfall, relative humidity may reach upto 100%.

II. Importance of water to biosphere

Water is an important contituent of the biosphere. Its importance is summarized as follows:

1. Water is an important, necessary and abundant constituent of the biosphere. The body of an organism is composed of about 70% of water by its weight. Water represents the most extensive medium for animal life.
2. The habitats of living organisms are aquatic or terrestrial ones is based mainly on the amount of

water present in the respective environment. On this basis plants are classified into hydrocoles (water loving), mesocoles (neither require excess or less) and xerocoles (dry situation).

3. Water acts as a solvent for the metabolic activities of living organisms.
4. Water serves as a vehicle for the transport of material within the bodies of organisms.
5. Water also acts as a regulator of temperature for plants and animals.

III. Hydrological cycle

This cycle is also called as water cycle. It is a balanced and continuous process of evaporation, transpiration, precipitation, surface run off and ground water movements. It is estimated that every year about 507 Tm^3 (tetra-cubicmeter) water gets evaporated and the same quantity of water is precipitated over the whole surface of the earth including land and oceans. Solar energy evaporates the water from soil, ground surface, vegetation and oceans into the atmosphere. Subsequent cooling and condensation of water vapour at higher altitudes produce clouds and precipitate as rain, hail or snow returns the water to the hydrosphere. Natural evaporation of water is 9%. The unending continuous circulation of the earth's water which leaves the surface as a gas (vapour) and returns as a liquid (water) or a solid (ice, snow and hail). Such a cyclic movement of water from earth to atmosphere and again back to the earth is referred as hydrological cycle or water cycle. The hydrological cycle (Fig. 2.2) involves following three major steps:Evaporation, condensation and precipitation.

1. **Evaporation:** The conversion of moisture from liquid to gas or from water to vapour is known as evaporation. The rate of evaporation depends upon the temperature (of both air and water), humidity

and movement of air. At higher temperature, the rate of evaporation increases but decreases with increase in the humidity whereas, the movement of air accelerates the rate of evaporation. Since 97% of all evaporation occurs in the ocean and remaining 3% on the land water bodies such as river, lakes, ponds, streams, dams, reservoirs etc., transpiration by plants and by the evaporation from animals.

2. **Condensation:** It is a process whereby the water vapour is converted into liquid form. For condensation, the air has to be saturated. For the formation of a droplet of water, it is necessary to have a surface on which condensation can take place. Water condenses in the form of dew drops on land. In air, the particles of dust, smoke, pollen and the most common bacteria help in water condensation. These particles are called as hydrospheric particles or condensation nuclei. As soon as air temperature drops, the water vapour molecules begins to condense around these particles or nuclei. The droplets grow rapidly as more and more water molecules accumulate and make them visible as clouds. Clouds

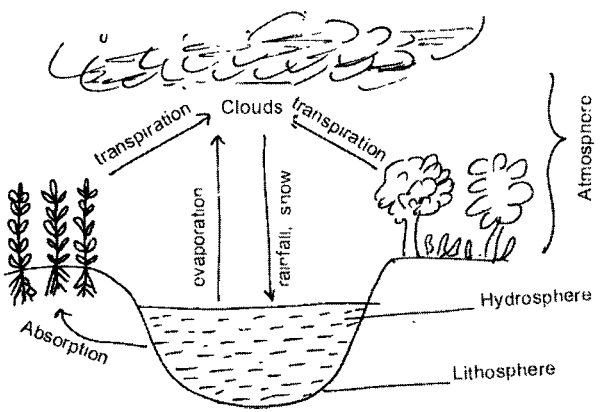


Fig. 2.2: Hydrological cycle

are therefore, a collection of minute droplets of water or tiny crystals of ice.

3. **Precipitation:** The water droplets can not fall to the ground because of their small size. But several million droplets join together to form a water drop. These water drops are larger in size and big enough to fall on the earth surface under the influence of gravity. About 78% of precipitation takes place on the land. The rain is most widely spread, common liquid form whereas snow, sleet, glaze, hail and ice are some of the solid forms of precipitation.

IV. Physico-chemical characteristics of water

Water is an important environmental factor on the earth. It has unique physical and chemical characteristics. The physical properties of water are its heat capacity, universal solvent, latent heat, surface tension, viscosity, thermal conductivity etc. and the chemical parameters include dissolved oxygen, free carbon dioxide, total alkalinity, salinity pH, hardness, ammonia, nitrates, nitrites etc. All these parameters are explained as follows:

I. **Physical characteristics of water:** These include heat capacity, solvent, latent heat, surface tension, viscosity etc. are enumerated here.
   1. **Heat capacity:** The specific heat of water is high. Water gets heated and cooled slowly. Due to this thermal stability, water regulates the temperature of plants and animals.
   2. **Solvent:** Water is a universal solvent. Many gases and chemical materials can be dissolved in it. It provides a vital medium to carry out the vital activities.
   3. **Latent heat:** It is the quantity of heat required to change a substance from solid to liquid state or from liquid to gaseous state without changing its temperature.

4. **Surface tension:** Water has highest surface tension.
5. **Viscosity:** Water has great viscosity that enables to protect the aquatic animals and plants against mechanical disturbances. The high viscosity also helps the planktonic organisms to float passively on the surface of water without the aid of any swimming organs.
6. **Thermal conductivity:** Water has highest heat conductivity hence it helps in distributing the heat uniformly over the entire body, so that the temperature of the whole body of the animal is maintained at a constant rate.
7. **Transparency:** Water is transparent when clean and without turbidity. The transparency enables the penetration of light to the depth upto which it is ultimately absorbed. The light is required for the growth of living organisms in plants, animals and micro-organisms.

II. **Chemical properties of water:** Water possess following chemical properties. These properties include pH, dissolved oxygen, free CO_2, etc.

1. **pH:** pH is the concentration of hydrogen ions in the water. It indicates the acidic or alkaline nature of water. The pH below 7 is acidic and above 7 is alkaline. The neutral pH is 7. Alkaline pH (from 7 to 9) is favourable for the growth of organisms whereas the acidic pH (from 2 to 6) retards the growth of animals. pH is measured by pH meter.
2. **Dissolved Oxygen:** It is required for the respiration of aquatic organisms. Oxygen in the atmosphere mixed into the water body through the process of aeration. It can be analysed by Wrinkler's method by titration.

3. **Free carbon dioxide:** It is necessary for the photosynthetic activities of plants. It is produced due to the decomposition of organic matter and the respiratory activities of aquatic plants and animals. Carbon dioxide combines with water and forms carbonic acid ($CO_2+H_2O \rightarrow H_2CO_3$) which influences the pH of water.
4. **Total alkalinity:** The total alkalinity is the sum of phenophthalein and methyl orange alkalinities. It shows the concentration of alkalies in the water.
5. **Salinity:** It is due to presence of various salts such as Na, K, Ca, Mg, S, Cl etc. in water in different proportions. Salinity shows the nature of water whether it is freshwater or marine. The salts and ions are responsible for the salinity. The salinity of freshwater is 0 to 9 ppt, brackishwater salinity ranges from 10 to 20 ppt and marine from 21 to 300 ppt.
6. **Hardness:** Hardness of water is also an important chemical property of water. It is mainly due to the presence of salts of calcium and magnesium in the water. It may be of two types: temporary and permanent hardness.

A. **Temporary hardness:** Temporary hardness of water is caused by the dissolved salts of calcium bicarbonate or magnesium carbonate in the water. It can be converted into the soft water by boiling at high temperature. During this process, soluble bicarbonates of calcium and magnesium are converted into insoluble carbonates of calcium and magnesium.

B. **Permanent hardness:** Permanent hardness of water is due to the dissolved chlorides or sulphates of calcium and magnesium. This hardness cannot be removed by boiling, it require

some specific chemical treatment such as alum treatment.

7. **Ammonia nitrites and nitrates:** These occur in the water body in dissolved form. These reflect the growth of plants and animals well. If their concentration is increased beyond the optimum level prescribed by the ecologist, it may be lethal to the animals.

Lithosphere

The word lithosphere refers to the layers of rocks on the earth's surface both on the continents and oceanic floors. Lithosphere forms a relatively thin (50-100 km thick) crust which is thicker in the contents than the ocean floor. Below the lithosphere lies the mantle which extends upto a depth of 2,900 km. Mantle like lithosphere can also be divided into (i). outer 100 to 400 km thick, asthenosphere (*i.e.* inner silicate layer) having materials rich in silica and magnesium and (ii) inner 2,400 to 2,750 km thick mesosphere which is transitional zone of mixed materials and silicates. The central part of the earth, core is about 3,500 km thick. The core consists of metals in liquid state due to high temperature and pressure.

Lithosphere (Fig. 2.3) though literally means a sphere of rocks is also involves the study of land forms (*i.e.*, forms of land surface) and the soil, actual medium for the growth

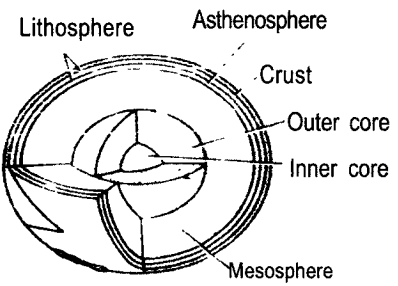


Fig. 2.3: Structure of earth showing lithosphere

of plants, animals and micro-organisms. We would discuss each of these aspects of lithosphere that is a source of various mineral resources and fuels as coal and oil. The soil cover on the land surface is important for the growth of plants and animals. The surface of land is covered by a variety of land forms *viz.*, mountains, plateaus, valleys and plains. Various land forms are important factor that determine the climate of an area and also pattern of land use.

I. Rocks

The most significant outer crust of the earth is lithosphere. The rocks are found in the earth crust. Its depth is about 16 km from earth surface. The rocks are made up of minerals.They are formed by the cooling of magna or lava.

Types of rocks

Rocks are classified on the basis of mode of their formation. There are three major types of rocks: igneous rocks, sedimentary rocks and metamorphic rocks.

1. **Igneous rocks:** These are formed by the solidification or cooling of magna or lava by strong earth forces. As the earth cooled to a solid crust, the original crust of the earth had igneous rocks. Igneous rocks are, therefore, known as primary rocks. Based on the conditions under which they cool, these rocks are subdivided into two types: plutonic rocks and volcanic rocks. The examples of plutonic rocks are granite, diorite, gabfro etc. and that of volcanic rocks are basalt, pumice, andesite etc.
2. **Sedimentary rocks:** These rocks are made up of sediments deposited usually on the floor of seas and lakes. Sediments may consists of particles of gravel, sand, silt or clay. The best examples of sedimentary rocks are limestone and sandstone.

3. **Metamorphic rocks:** The metamorphic rocks are those which are formed by the changes in pre-existing igneous or sedimentary rocks, when they are subjected to extreme heat or pressure or both. Limestone gets converted into marble. Similarly, sandstone gets metamorphosed to quartzite. All these are examples of metamorphic rocks.

Rock cycle: All rocks originates from the earth surface and form igneous rocks. These rocks are eroded by various agents. This eroded material changes into sedimentary rocks at some places and points. Either of the two rocks are likely to be changed into metamorphic rocks in due course of time. A change into sedimentary rocks takes place at the earth surface and conversion into metamorphic rocks takes place within the earth crust. These sedimentary rocks again are buried too deep and form igneous rocks. Thus, the conversion of one rock into another under different conditions is known as rock cycle (Fig. 2.4).

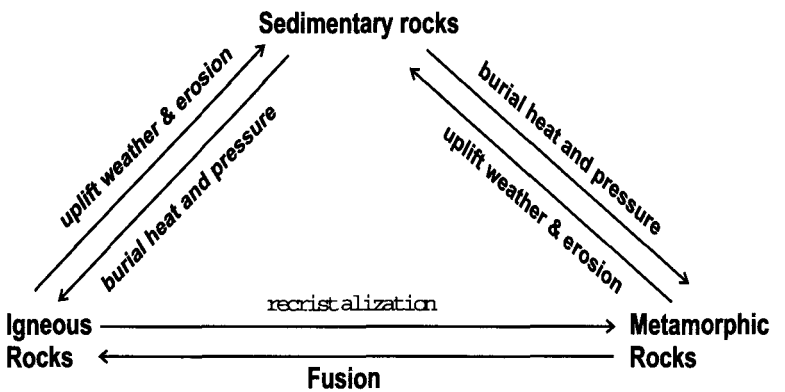


Fig. 2.4: Rock cycle

II. Soil

Soil is a basic natural resource. The plants grow in soil that has an important place in the biosphere. It is a life

zone on the earth. Soil is a mixture of solid, liquid and gaseous substances. It has both the living organisms and non-living soil where bio-geo-chemical cycles take place. Such a cycling of nutrients over long ages keep soil habitable for human civilization. Soil is a final product of interactions between the weathering of rocks, climate, plants, animals and micro-organisms. For the formation of soil a long period of time is required.

Components of soil: It is not merely a group of mineral particles but also has a biological system of living organisms as well as some other components. It is, thus, preferred to call it soil complex, which has the following five categories of components:

1. **Minerals:** The minerals present in the soil are basically derived from the parent rocks by varying degrees of breakdowns. The minerals are present mainly in the form of inorganic salts *viz.*, chlorides, nitrates, sulphates, phosphates and carbonates.
2. **Humus:** It is an organic compound derived from addition of material from organisms *i.e.*, plants, animals and micro-organisms. A soil containing much humus is said to be rich and is good for growing crops.
3. **Soil water:** Soil water is the water present in the soil with its dissolved solids, liquid and gases. Soil water is held by capillary and absorptive forces. Depending upon the water requirements, the plants are ecologically divided into hydrophytes, mesophytes and xerophytes. Soil water, in fact, is a dilute solution of many organic and inorganic compounds which is the source of plant mineral nutrients.
4. **Soil atmosphere:** The soil is made up of tiny particles. In these, various gases specially carbon dioxides and oxygen are also present. In the dry soil,

the carbon dioxide concentration is more while in wet soil, the proportion of dissolved oxygen and carbon dioxide is 1:1.

5. **Biological system:** Each soil has a specific flora and fauna of bacteria, fungi, algae, protozoa, nematodes, oligochaetes, molluscs and arthropods.

Soil formation: Soil is a very special and important factor among the physical factors of the environment. It is formed by the physical, chemical and biological processes. The whole process of soil formation is divided into two phases *viz.*, i. weathering of rocks where the break down of bigger rocks into fine, smaller mineral particles takes place and ii. soil development or pedogenesis which is the modification of the mineral matter through interaction between the biological, topographic and climatic factors that ultimately lead to the development of a great variety of soil types.

i. **Weathering of soil forming rocks:** Soil formation starts by the weathering of parent rocks by some physical, chemical and biological agents because of which the soil forming rocks are broken down into small particles called 'regoliths'. The weathering processes are physical as well as chemical.

A. Physical weathering processes

These may be of the following types:

(a) **Wetting and drying:** It is the disruption of layer into pieces of minerals which swell up after wetting.

(b) **Heating and cooling:** It occurs particularly in dry climate, where due to sun heating, large boulders and flake are formed at the rock surfaces.

(c) **Freezing:** This is the disruption of porous, lamellar or vesicular rocks by frost shutter due to expansion of water during freezing.

(d) **Glaciation:** The glaciation causes physical erosion of rocks through the grinding process.

(e) **Solution:** Some mobile components of rocks *viz.*, calcium chlorides, sulphates etc. are simply removed by the agents like water in solution.

(f) **Sand blast:** In desert, the rocks are disrupted by the physical action of wind, sand etc.

B. Chemical weathering

The chemical weathering is more complicated than the physical weathering. It occurs simultaneously with physical weathering and continues much beyond the limit. During chemical weathering, a chemical transformation or decomposition of parental mineral material into the new mineral complexes occurs. Chemical weathering requires the presence of moisture and air as essential factors. The chemical weathering involves several processes *viz.*, hydration, hydrolysis, oxidation, reduction, carbonation and chelation.

(i) **Hydration:** Because of hydration, the rocks swell up. This swelling causes the disruption of sandstones.

(ii) **Hydrolysis:** In this process, the components like alumina-silicates of rock break down, during which elements such as potassium and surplus silicon are washed out giving rise to simple mineral matter like clay aluminosilicates *e.g.*, hydrolysis of orthoclase to kaolinite.

(iii) **Oxidation-reduction:** The oxidation and reduction reactions cause the disruption of rocks.

(iv) **Carbonation:** During the metabolism of organism, some chemicals are produced which bring about the process of carbonation *e.g.*, $CaCO_3$ to $Ca(HCO_3)_2$ which leads to the formation of solution.

(v) **Chelation:** Some chemicals produced through biochemical activity of microorganisms like lichens, bacteria etc. are able to dissolve mineral components of the rocks. The metals dissolved with organic

products of microbial activity are referred as chelates. *e.g.*, acids produced by the lichens and bacteria have strong chelating properties.

Soil development or pedogenesis

During weathering, the rocks are broken down into smaller particles. The weathered material undergoes further a number of changes under a very complex process known as pedogenesis or soil development. In the process of weathering, physical and chemical factors are involved, while pedogenesis is largly a biological phenomenon. During this phenomenon, living organisms such as lichens, bacteria, fungi, algae, micro-arthropods, molluscs, as a result of secretion of organic acids, enzymes, CO_2 production and addition of organic matter after their death, bring about the biochemical, biophysical and geo chemical processes. Due to all these, the crust of weathered rock debris are converted into true soils, consisting of complex mineral matrix in association with a variety of organic compounds and a rich micro-organism population. Thus, during pedogenesis, various organic compounds, dead organic matter and living organisms etc. are added to the mineral matter. As a result of mineralization of dead organic matter, the minerals are then gradually added to different layers of developing soil. This soil when fully developed can be seen having a number of layers or horizons of a soil and can be seen collectively super imposed one above the other and exposed in a pit section. The soil profile (Fig. 2.5), according to the present classification, consists of five main horizons: 'O' horizon, 'A' horizon, 'B' horizon, 'C' horizon and 'R' horizon.

III. Importance of soil to the biosphere

Soil plays a very important role in determining the nature and composition of biosphere. The importance of soil to the biosphere is as follows:

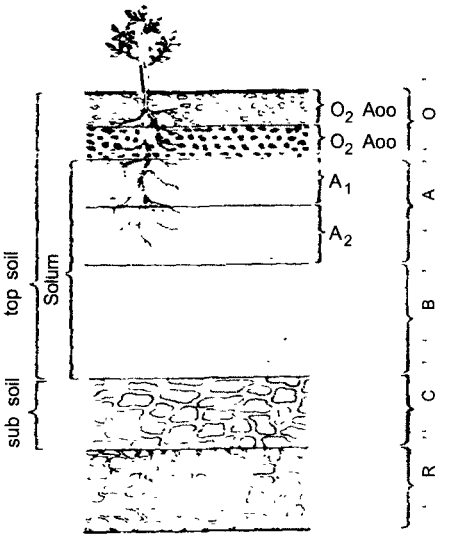


Fig. 2.5: Different horizons of a soil profile

1. **Mechanical support:** Soil is a solid substratum and provides mechanical support to plants as well as to animals.
2. **Water holding capacity:** The porosity and water holding capacity enables it to retain rainwater. In drier period, soil serves as a resevoir on which a variety of living organisms depend.
3. **Ion-exchange capacity:** This capacity of soil is responsible for retaining micro- and macro-nutrients in the soil for longer durations. The ion-exchange capacity of soil also helps in preventing excessive leaching of nutrient ions and also in maintaining pH of soil.
4. **Fertility:** Soil contains bacteria including organo-leptic bacteria, nitrifying bacteria, pigmented microbes, nitrogen fixing organisms and a number of fungi and protozoans. Activity of these microbes keep the soil in a fertile state. Waste materials or

pollutants discarded in the soil are also effectively decomposed by these microbial organisms.Thus, the soil has great importance to our biosphere.

QUESTIONS

1. Explain the abiotic and biotic factors of the environment.
2. Define atmosphere and describe the major zones of atmosphere.
3. What is hydrosphere? Explain global distribution of water.
4. Give an account of physico-chemical characteristic of water.
5. Give an account of soil formation.
6. Explain the importance of soil to the biosphere.
7. Write short notes on:
   A. Types of rocks
   B. Components
   C. Hydrological cycle
   D. Intra-specific and inter-specific relationships

BIOSPHERE

Biosphere is the life zone of the earth and is an important and unique realm of our natural environment. Biosphere refers to that part of the earth in which all life forms exist. The organisms comprising the biosphere are mostly found in the relatively narrow zones of contact between the atmosphere, lithosphere and hydrosphere. This narrow and extremely complex zone lying at or close to the interfaces between atmosphere, hydrosphere and lithosphere is known as biosphere. Since the life is possible only in this layer, it is vital for us. Irrespective of the location on the earth (whether it is pond, lake, ocean, forest or desert) and the size, the organisms (plants, animals, micro-organisms) and their physical environment interact with each other in an orderly manner. There is a continuous flow of energy and matter between them. At every location, there are some basic principles that regulate the structure and function of this integrated system, the ecosystem which is comprising of the living (biotic) and non-living (abiotic) components. The basic plan of the organization of a typical ecosystem and the ways by which the energy and matter flow through its various components are discussed here.

ECOSYSTEM

The overall view of this type of approach is that the living organisms and their non-living environment are

inseparably interrelated and interact with each other. Keeping this in view, the term 'ecosystem' was proposed by A.G. Tansley in 1935. However, the term ecosystem is most preferred, where 'eco' implies the 'environment' and 'system' implies an interacting and inter-dependent complex. The term ecosystem was defined by many workers. According to A.G.Tansley, the system resulting from the integration of all the living and non-living factors of the environment is referred to an ecosystem. Odum (1971) defined ecosystem as, the basic functional unit of ecology which includes both the living organisms and non-living environment, each one influencing the properties of the other and is necessary for the maintenance of life. Madhavan(1974) defined ecosystem as 'the sum total of living organisms, the environment and the process of interaction between and within all the parts of the system'.

Thus, any unit that includes all the organisms *i.e.*, the communities in a given area, interacts with the physical environment, so that the flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles within the system is known as ecological system or ecosystem. An ecosystem may, thus, be as small as a pond, a crop land, or as large as an ocean, desert or forest. These unit ecosystems are simply separated from each other and practically no functional boundaries between them. The ecosystem has unique characteristics features. These are as follows:

1. It is terrestrial or aquatic in habitat.
2. The basic functions of the ecosystem are separated in space. In some ecosystems, the basic functions are partially separated in time. For example, in a forest ecosystem, photosynthesis occurs in the upper stratum which receives sunlight but only small part of the photosynthesis is directly used by the plants, herbivores and parasites feeding on foliage and new

wood. Most of this material as leaves, wood, seeds and root finally reaches the litter and soil which together constitute a well defined heterotrophic system.

TYPES OF ECOSYSTEM

Different types of ecosystems are found in the nature (Fig. 3.1). These may be classified into two categories: i. Natural ecosystems and ii. Artificial ecosystems.

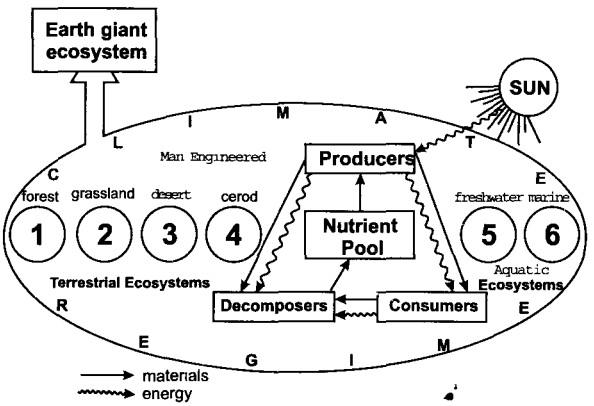


Fig. 3.1: Types of ecosystem

I. Natural ecosystems

These ecosystems are being operated by themselves under natural conditions. Based on the particular kind of habitat, these are further divided as terrestrial and aquatic ecosystems.

1. **Terrestrial ecosystems:** Terrestrial ecosystems are also referred as biomes. A biome is the largest terrestrial ecological unit which is characterized by the interactions of flora, fauna and abiotic components. The major biomes are grassland, forest, desert, mountain, cave and tundra biome.
2. **Aquatic ecosystems:** Aquatic ecosystems are those where the base of ecosystem is water. These systems

are classified into three main types *viz.*, freshwater, brackishwater and marine habitats.

A. **Freshwater habitats:** Freshwater habitats are those where freshwater is prominent. These habitats are divided into two categories:
   i. **Lotic habitats:** These are running water habitats *e.g.*, river, streams and springs.
   ii. **Lentic habitats:** These are standing water habitats. The lentic habitats are lakes, ponds and reservoirs.

B. **Brackish water habitats:** Brackishwater habitats are those habitat which are intermediate between freshwater and marine habitats. The best example is an estuary.

C. **Marine habitat:** Marine habitats are those habitats where the water has higher salinity *e.g.*, sea and ocean. These are the largest ecosystem on the earth.

II. Artificial ecosystems

These systems are maintained artificially by man whereby the addition of energy and planned manipulations, the natural balance is disturbed regularly *e.g.*, croplands like maize, wheat, rice-fields etc., where man tries to control the biotic community as well as the physico-chemical environment are artificial ecosystems. Besides, there is also one more ecosystem, which is developing very rapidly is 'space ecosystem'.

Pond ecosystem

Ponds are small bodies of water. They have a great deal of vegetation which increases with the age of the pond. The depth of the pond water varies from few inches to few meters. Ponds are not stratified as the force of winds keeps the entire mass of water in circulation. It results in entire distribution of oxygen, carbon dioxide and temperature. Shallow water ponds receive light upto the bottom and

get heated up. Both light and temperature govern the productivity of the pond. The pond has two types of components *viz.*, abiotic and biotic components.

1. Abiotic components

The abiotic components of the pond ecosystem include soil, water and their physico-chemical characteristics including temperature, turbidly, pH, dissolved oxygen, free carbon dioxide, total alkalinity, hardness, ammonia, nitrate, nitrites, phosphates etc. On the basis of penetration of light in the pond, the water column can be distinguished into i. littoral zone, ii. sublittoral zone, iii. limnetic zone and iv. profundal zone (Fig. 3.2).

i. **Littoral zone:** It consists of shallow water and the bottom in the shore area where sunlight penetrates. It includes rooted vegetation.
ii. **Sub-littoral zone:** It is present below the littoral zone and contains cold water.
iii. **Limnetic zone:** It is upto the depth of effective light penetration where the rate of penetration of light is equal to the rate of photosynthesis.
iv. **Profundal zone:** It is the deep water area where sunlight does not penetrates and, therefore, this zone is non-photosynthetic zone. Generally, it is not found in the ponds.

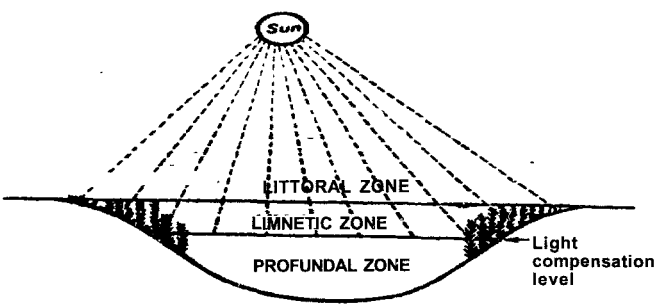


Fig. 3.2: Zones in a pond

2. Biotic Components

This is indeed the trophic structure of an ecosystem where living organisms are distinguished on the basis of their nutritional relationship. From this trophical (nutritional) point of view, an ecosystem has two components *viz.*, autotrophs and heterotrophs.

A. **Autotrophs:** The autotrophs are those living organisms which fix the solar energy by the process of photosynthesis. These are green plants. The members of the autotrophic components are known as producers.

B. **Heterotrophs:** The heterotrophs are known as consumers, as they consume the matter built up by the producers (autotrophs). The consumers are further categorized as macro- and micro-consumers.

   i. **Macro-consumers:** The macro-consumers are of three types: primary, secondary and tertiary consumers. The primary consumers are herbivores which eat only green plants. The secondary consumers are carnivores which eat small animals. The tertiary consumers are omnivores which eat both plants and animals. All macro-consumers are phagotrophic in nature which include chiefly animals that ingest other organic and particulate organic matter.

   ii. **Micro-consumers:** These are popularly known as decomposers. They are saprotrophs and include chiefly bacteria and fungi actinomycetes. They break down the complex compounds of dead or living protoplasm, absorb some of the decomposition or break down products and release inorganic nutrients in the environment, making them available again to autotrophs. (Fig. 3.3).

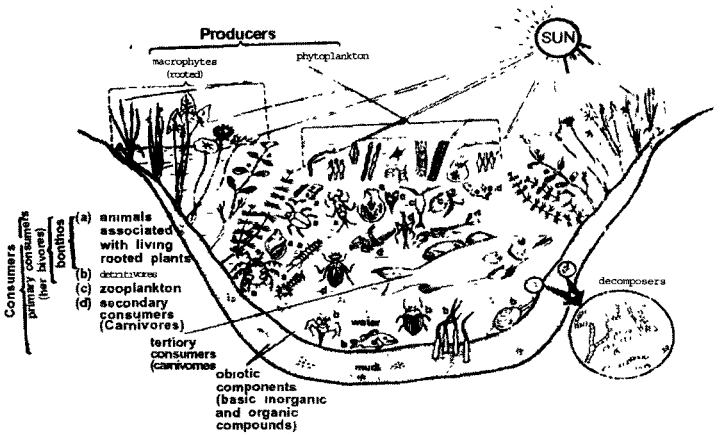


Fig. 3.3: Pond ecosystem

3. Food chains

The transfer of food energy from the producers, through a series of organisms *i.e.*, from herbivores to carnivores to decomposers with repeated eating and being eaten is known as food chain. Producers utilize the solar energy which is transformed to chemical form, ATP during photosynthesis. Thus, green plants occupy the first trophic (nutritional) level, called primary producers.This energy is then utilized by the plant eaters, the herbivores which constitute the second trophic level, the primary consumer level and called the primary consumers (herbivores). The herbivores, in turn, are eaten by the carnivores, which constitute the third trophic level, the secondary consumers level and called secondary consumers (carnivores). These in turn, may be eaten by still other carnivores at tertiary consumers level (tertiary consumers means carnivores). Some carnivores are eating the producers as well as the carnivores at their lower level in the food chain. Such organisms may occupy more than one trophic level in the food chain. Thus, in any food chain, energy flows from primary producers to

primary consumers (herbivores), from primary consumers to secondary consumers (carnivores) and from secondary consumers to tertiary consumers (carnivores/omnivores) and so on. This simple chain of eating and being eaten is known as food chain. At each transfer, a large proportion, 80-90% of the potential energy is lost as heat. Therefore, the number of steps or links in a sequence limited usually to 4 to 5. Shorter the food chain, greater the available energy. Two basic type of food chains occur in nature: grazing food chain and detritus food chain.

1. **Grazing food chain:** A grazing food chain starts from a green plant base, goes to grazing herbivores and from herbivores to carnivores (animal eaters). Ecosystem with such type of food chain is directly dependent on an influx of solar radiation. Most of the ecosystems in nature follow this type of food chain. These food chains are very important in the ecosystem. The sequence of the grazing food chain is represented as follows:

    1. Green plants → Herbivores → Carnivores
    2. Phytoplankton → Zooplankton → Fish
    3. Grass → Rabbit → Fox

2. **Detritus food chain:** This type of food chain starts from dead organic matter into micro-organisms and then to organisms feeding on detritus (detritivores) and their predators. Such food chains are thus less dependent on direct solar energy. These depend chiefly on the influx of organic matter produced in another system. This type of food chain operates in decomposing accumulated litter in the temperate forests. The sequence of detritus food chain is as follows:

Dead organic matter → Micro-organisms → Detritivores

It has been observed that the base of food chain is always formed by the autotrophs (producers). The body and apex consists of heterotrophs. Their arrangement mainly follows the pattern as under:

Producers → Herbivores → Carnivores

Importance of food chains

1. Food chain studies help in understanding the feeding relationships and interaction between the organisms in an ecosystem.
2. It also helps in understanding the mechanism of energy flow.
3. Food chains also help in studying the movement of toxic substances in the ecosystem and in understanding the problem of biological magnification.

4. Food webs

Food webs are the interlocking pattern of organisms. However, food chains in natural conditions never operate as isolated sequence but are inter-connected with each other, forming some sort of interlocking pattern, which is referred as a food web.

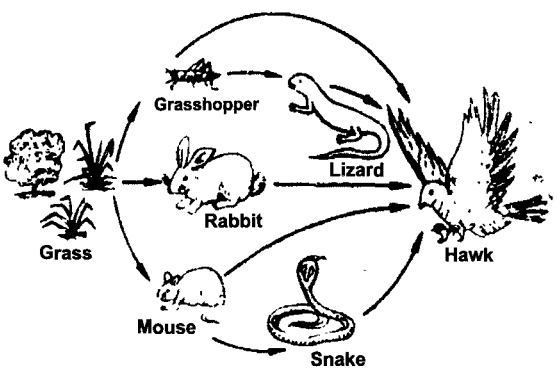


Fig. 3.4: Food web in a grassland ecosystem

Under natural conditions, the linear arrangement of food chains hardly occur and these remain indeed interconnected with each other through different types of organisms at different trophic levels. For example, in grazing food chain of a grassland, in the absence of rabbit, grass may also be eaten by mouse.The mouse in turn may be eaten directly by hawk or by snake first which is then eaten by hawk. Thus, in nature there are alternatives, which all together constitute some sort of interlocking pattern, the food web. In such a food web in grassland (Fig.3.4). There may be five linear food chains:

Grass → grasshopper → hawk
Grass → grasshopper → lizard → hawk
Grass → rabbit → hawk
Grass → mouse → hawk
Grass → mouse → snake → hawk

A similar food web in a pond with different inter-linked food chain is shown in Fig. 3.5. The food webs are very important in maintaining the stability of an ecosystem in nature. For example, decrease in population of rabbit would naturally cause an increase in the population of mouse. This may decrease the population of consumer (carnivore) that prefers to eat rabbit. Thus, alternatives (substitutes) serve for the maintenance of stability of the ecosystem.

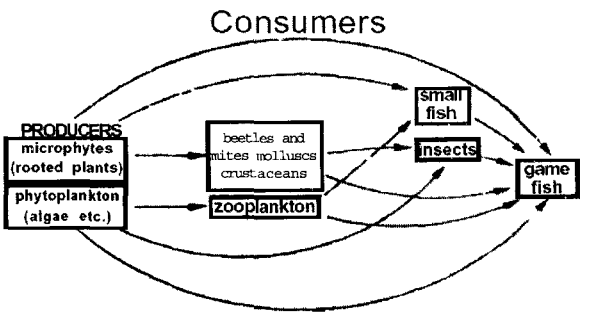


Fig. 3.5: Food web in a pond

Moreover, a balanced ecosystem is essential for the survival of all living organism of the system. For a while, primary consumers (herbivores) had not been in nature, the producers would have perished due to overcrowding and competition. Similarly, the survival of primary consumers is linked with the secondary consumers (carnivores) and so on. Thus, each species of any ecosystem is indeed kept under some sort of a natural check, so that the system may remain balanced.

The complexity of any food web depends upon the diversity of organisms in the system. More the alternative, more would be the interlocking pattern. In deep oceans, seas etc.where we find a variety of organisms. The food webs are more complex. The food webs are very important for maintaining stability of the ecosystems.

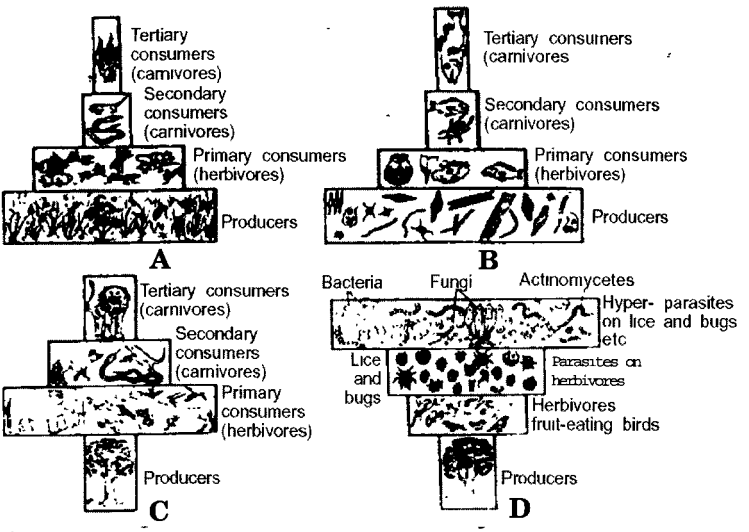
3. Ecological Pyramids

The concept of ecological pyramid was developed by Elton (1927) and hence the ecological pyramid are also called 'Eltonian pyramids'. These ecological pyramids provide a common denominator for the comparison of different communities. The ecological pyramids also show the relationship between species and individuals or biomass. The diversity of species and dispersal of individual of each species in the community are also depicted.

The trophic structure and function at successive trophic levels *i.e.*, producers, herbivores and carnivores may be shown graphically by means of ecological pyramids where the first or producer level constitutes the base of the pyramid and the successive levels making the apex and thus form the pyramids. Such pyramids are referred to as ecological pyramids. Trophic structure is the interaction of food chain and the size metabolic relationship between the linearly arranged various biotic components of an ecosystem.

Generally, there are three types of ecological pyramids *viz.*, 1. pyramid of numbers, 2. pyramid of biomass and 3. pyramid of energy. The pyramid of number shows the number of individual organisms at each level, the pyramid of biomass is total dry weight of living matter and the pyramid of energy means the rate of energy flow at successive trophic levels. The pyramid of numbers and biomass may be upright or inverted, depending upon the nature of the food chain in the particular ecosystem, whereas, the pyramids of energy are always upright.

A. **Pyramids of numbers:** The pyramid of numbers is formed when the relationship between producers, herbiveres and carnivores at successive trophic levels is shown in terms of number. The pyramids of numbers in different kinds of ecosystems are shown in the Fig. 3.6 (A-D).



A. Grassland ecosystem, B. Pond ecosystem,
C. Forest ecosystem and D. Parasitic food chain.

Fig. 3.6: Pyramids of numbers in different ecosystem

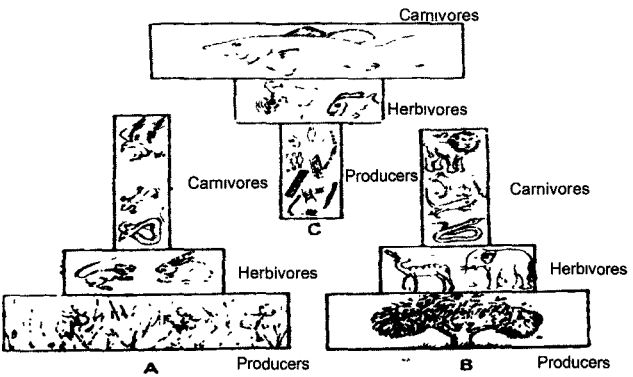
In a grassland (Fig. 3.6A) the producers are grasses and are always maximum in number. This number then shows a decrease towards the apex, as the primary consumers (herbivores) like rabbits, mice etc. are lesser and thus the pyramid is upright. The producers, mainly grasses, are greater in number than the herbivore, the secondary consumers, snakes and lizards are lesser than the rabbits and mice. Finally, the top (tertiary) consumers hawks or other birds are least in number. Hence, the pyramid becomes upright.

Similarly, in a pond ecosystem (Fig. 3.6B), the pyramid is upright. The producers are mainly phytoplankton like algae, bacteria etc. are maximum in number. The herbivores are smaller fish, rotifers etc. are lesser in number than the producers and the secondary consumers (carnivores) *viz.*, small fish eating each other, water beetles etc. are lesser in number than the herbivores. Finally, the tertiary (top) consumers, the bigger fish are least in number.

In a forest ecosystem (Fig. 3.6C), however, the pyramid of numbers is somewhat different in shape. The producers which are mainly large sized trees, are lesser in number and form the base of pyramid.The herbivores which are fruit eating birds, elephants, deers etc. are more in number than the producers. Then there is a gradual decrease in the number of successive carnivores, thus, making the pyramid again upright.

In a parasitic food chains (Fig. 3.6D), the pyramids are always inverted. This is due to the fact that a single plant may support the growth of many herbivores and each herbivores in turn may provide nutrition to several parasites which support many hyperparasites. In this way, from producer to consumer, there is always reverse position, that is, the number of organisms gradually shows an increase making the pyramid inverted in shape.

B. **Pyramids of biomass:** The pyramids of biomass are of fundamental type and show the quantitative relationships. The pyramids of biomass in different types of ecosystem is shown in Fig. 3.7 (A-C). In grasslands and forests (Fig. 3.7 A and B), generally, there is a gradual decrease in biomass of organism at successive levels from the producers to the top carnivore. Thus, these pyramid are upright. In a pond as the producer are small organisms, their biomass is least and biomass value gradually shows an increase towards the apex of the pyramid, thus, making the pyramid inverted in shape (Fig. 3.7C).



A. Grassland B. Forest and C. Pond

Fig. 3.7: Pyramids of biomass in different ecosystem

C. **Pyramids of energy:** The pyramids of energy give the best picture of overall nature of ecosystem. Here, the number and weight of organisms at any level depend not on the amount of fixed energy present at any one time in the level just below but rather on the rate at which food is being produced. The pyramid of energy is a picture of the rates of passages of food mass through the food chain. In shape, the pyramid is always upright (Fig. 3.8). In most of the cases, there is always a gradual decrease in the

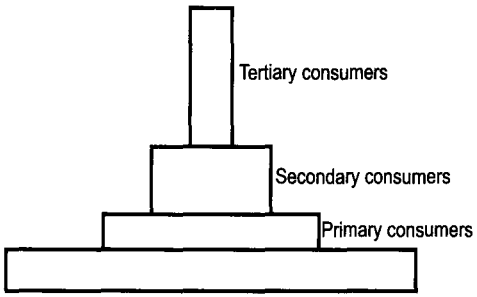


Fig. 3.8: Pyramid of energy

energy content at successive trophic levels from the producers to various consumers.

ECOLOGICAL ENERGETICS

The ecological energetics determines the fate of radiant energy reaching on the earth surface. The energy used for all life processes of organisms is derived from the solar radiation. A fraction *i.e.*, about 1/50th millionth of the total solar radiation reaches to the earth's surface. Solar radiation travels through the space as waves, and while travelling most of the radiations are lost in the space. The energy reaching on the earth's outer surface of the earth consists of largley visible light (390-760 nm) and infra-red rays. Plants absorb strongly the blue and red light (400-500 nm and 600-700 nm, respectively). Only 1% sunlight is used in the process of photosynthesis by the plants and its small fraction supports all life on the earth. The rest of the solar energy radiations are absorbed as heat by ground vegetation, water or air. In fact only about 0.02% sunlight reaching in the atmosphere is used in the photosynthesis.

A large proportion of potential energy is lost during its transfer to different levels of consumers. At each level some energy is used in respiration for the maintenance of body actions. Therefore, a very little amount of energy is used by consumers in a large food chain. Indeed, when

plant is eaten by a herbivore, all the plant material cannot be converted into the flesh or energy of the herbivore, much of this is excreted. Similarly, when a herbivore is eaten by carnivore 1 kg of flesh of a herbivore does not make 1 kg of the flesh of a carnivore.This is because at each trophic level in food chain, only a small part of energy is stored in the form of food and can be utilized to build up new protoplasm of the consumer, the major portion is being lost as heat. From this, it is learnt that herbivores get the energy transferred from the sun to producer and from producers to themselves and they must eat a large number of plants to get their full requirement of energy. Similarly, a carnivore must eat a large number of herbivores to get the energy it needs. It is interesting to note that such inter-conversion of energy closely follows the laws of thermodynamics. Consequently, the energy used for all life processes is derived from the solar radiation because of which life on the earth is maintained.

1. According to first law of thermodynamics, the energy can neither be created nor be destroyed, but is transformed from one form to another.
2. According to second law of thermodynamics, the energy flows from a region of higher concentration to the lower one and work is performed through degradation of energy.

ENERGY FLOW IN ECOSYSTEM

The behaviour of energy in ecosystem can be referred as energy flow. In other words, the transfer of energy from one trophic level to another trophic level is known as energy flow. The flow of energy in an ecosystem is unidirectional. This means that it flows from the producer level to the consumer level. Energy never flows in reverse direction. Hence, the energy can be used only once in the ecosystem, but the mineral circulate and recirculate many times in the ecosystem. From energetics point of view, it is essential

to understand (i) the efficiency of the producers in absorption and conversion of solar energy, (ii) the use of this converted chemical form of energy by the consumers, (iii) the total in put of energy in the form of food and its efficiency of assimilation, (iv) the loss through respiration, heat, exertion etc., and (v) the gross and net production.

The flow of energy through an ecosystem can be represented diagramatically by different models.These flow charts are known as energy flow models. There are three models suggested by the ecologists for the study of energy flow in the ecosystem. These three models are *viz.*, i. Single channel energy model (Odum, 1971), ii. Y-shaped or two channel energy flow model (Odum, 1963) and iii. Universal model of energy flow (Odum,1968).

SINGLE CHANNEL ENERGY FLOW MODEL

The single channel model of energy is also referred as 'boxes and pipes graphic model'. This model was suggested by Odum (1971). In this model, the energy flows at three trophic levels *viz.*, primary producers (green plants), primary consumers (herbivores) and secondary consumers (carnivores). According to this model, a large amount of energy is lost at each trophic level. It is estimated that 80 to 90% of energy is lost when it is transferred from one trophic level to another. Hence, the amount of energy available decreases from one step to another. When the food chain is short, the final consumer may get a large amount of energy but when the food chain is too large, the final consumer may get a much less amount of energy.

The principles of food chains and working of the two laws of thermodynamics can be better made clear by means of energy flow diagrams (Figs. 3.7 and 3.8). From the Fig. 3.9, two things become clear, (i) there is one way street along which energy flows (uni-directional flow of energy).

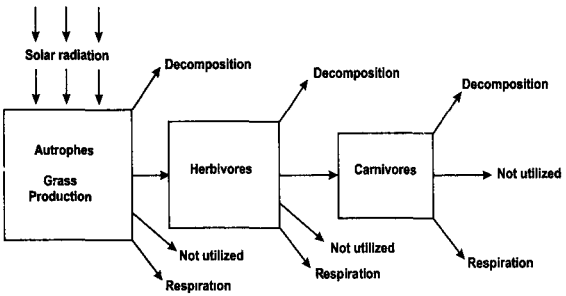
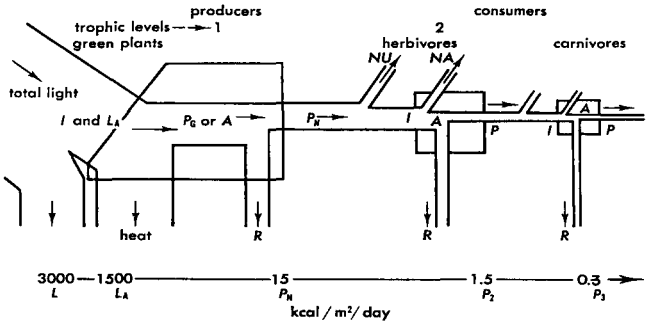


Fig. 3.9: Energy flow in a lake

The energy that is captured by the autotrophs does not revert back to solar input and that which passes to the herbivores does not pass back to the autotrophs. As it moves progressively through the various trophic levels, it is no longer available to the previous level. Thus, due to one way flow of energy, the system would collapse, if the primary source, the sun, is cut off, (ii) there occurs a progressive decrease in the amount of energy at each trophic level. This is accounted largely by the energy dissipated as heat in the metabolic activities and measured here as respiration coupled with unutilized energy.

In Fig. 3.10, the boxes represent the trophic levels and the pipes depict the energy flow in and out of each level. The Fig. 3.10 represents a very simplified energy flow model of three trophic level, from which it becomes evident that the energy flow is greatly reduced at each successive trophic level from producer to herbivore and then to carnivore. Thus, at each transfer of energy, from one level to another, major part of energy is lost as heat or as any other form. There is a successive reduction in the energy flow, whether we consider it in terms of flow (*i.e.*, total energy input and total assimilation) or secondary production and respiration components.

Thus, of the 3,000 Kcal of total light falling upon the green plants, approximately 50% (1,500 Kcal is absorbed).



I - total energy input;
L_A - light absorbed by plant cover;
P_G - gross primary production;
A - total assimitation;
PN - net primary production;
P - secondary (consumer) production;
NU - energy not used (stored or exported);
NA - energy not assimilated by consumers (egested);
R - respiration. (After E.P. Odum, 1963).

Fig. 3.10: Single channel energy flow model

Of which only 1% (15 Kcal) is converted at first trophic level. The net primary production, thus is nearly 15 Kcal. Secondary productivity (P2 and P3 in the diagram) tends to be about 10% at successive consumer trophic levels *i.e.*, herbivores and carnivores. Although efficiency may be sometimes higher as 20% at the carnivore level as shown in the diagram (P3=0.3 Kcal). Thus, it becomes evident from the Figs. 3.8 and 3.9, that there is a gradual reduction in energy flow at successive trophic levels. Consequently, shorter the food chain, greater would be the available food energy and with an increase in the length of food chain, there is a corresponding more loss of energy.

Y-SHAPED ENERGY FLOW MODEL

Odum (1963) gave a generalized model of Y-shaped or 2 channel energy flow model. This model is based on the

two types of food chains *viz.*, (i) grazing food chain and (ii) detritus food chain. The grazing food chain begins with green plants base going to herbivorous and then to carnivorous, whereas, the detritus food chain starts with dead organic matter acted by microbes, then passing to detritivores and their consumers (predators). Fig. 3.11 shows Y-shaped energy flow model. In each Y-shaped model, one arm represents the herbivore food chain and the other decomposer (detritus) food chain.The two arms differ fundamentally, in the way in which they can influence primary producers. In this model, the grazing and detritus food chains are sharply separated. This figure contrasts the biomass energy flow relationship in the sea and forest. In the marine bay, the energy flow through the grazing food chain be longer than the detritus pathway (forest), whereas, in reverse, the forest, in which 90% or more of the net primary production is normally utilized in detritus food chain. Thus, in marine ecosystem, the grazing food chain is the major pathway of energy flow, whereas, in the forest ecosystem, the detritus food chain is more important.

The Y-shaped model further indicates that the two food chains are in fact, under natural condition, not completely isolated from one another. For instance, dead

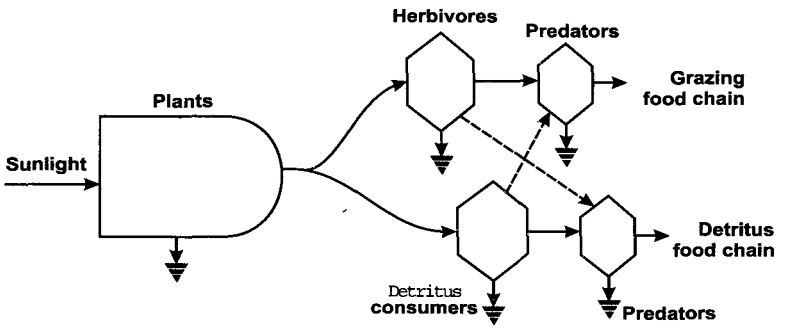
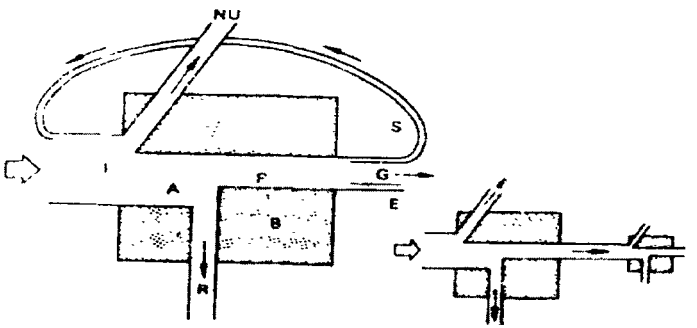


Fig. 3.11: Y-shaped energy flow model

bodies of small animals incorporated in the detritus food chain as do the faeces of grazing food chain animals. The importance of the two food chains may differ in different ecosystems. In some grazing is more important and in others detritus is major pathway. Thus, we can say that the two food chains are not isolated from each other. This Y-shaped model is more realistic and practical working model than the single channel model because (i) it confirms the basic stratified structure of ecosystems, (ii) it separates the grazing and detritus food chains (direct consumption of living plants and utilization of dead organic matter respectively) in both time and space, (iii) the micro-consumers (absorptive bacteria, fungi) and the macro-consumers (phagotrophic animals) differ greatly in size and metabolic relations. The Y-shaped energy flow model is applicable to both terrestrial and aquatic ecosystems.

UNIVERSAL MODEL OF ENERGY FLOW

Fig. 3.12 represents the universal model of energy flow. This model was suggested by E.P. Odum in 1968. Such a



I	- input or ingested energy;	NU	- not used;
A	- assimilated;	P	- production;
R	- respiration;	B	- excreted;
G	- growth;	S	- stored energy;
E	- Exerted energy. (After E.P. Odum, z1968).		

Fig. 3.12: Universal model of energy flow

model may depict food chain which is already shown in single and Y-shaped energy flow systems. In the Fig. 3.12, the shaded-box labelled 'B' represents the living structure or biomass of the components. The total energy input or intake is indicated by 'I' which is light for strict autotrophs and organic food for strict heterotrophs.

This universal model is applicable to any living component, whether a plant, animal or micro-organisms. This model of energy flow can be used in two ways: (i) It can represent a species population, in which, the appropriate energy inputs and links with the other species would be shown as a conventional species oriented food web diagrams. (ii) The model can represent a discrete energy level in which, the biomass and energy channels represent all or parts of many populations supported by the same energy sources, for example, foxes usually obtain part of their food by eating plants (fruit etc.) and part by eating herbivores (rabbit, field mice etc.). A single box diagram is used to represent the whole population of foxes, on the other hand, two or more boxes as shown on the right of Fig. 3.12 would be employed, if we wish to separate the metabolism of a population into two or more trophic levels in accordance with the proportion of plants and animals consumed.

The energy flow in the ecosystem, shared that these models depicts the basic pattern of the energy flow in the ecosystem. In practice, under natural conditions, the organisms are interrelated in such a way that several food chains are interlocked which results into a complex food web. The complexity of food web depends on the length of the food chain.The interlocking pattern of such several chains in the food web of an ecosystem would lead to a multichannel flow of energy. Thus, in practice, under field conditions, we might face difficulties in measuring the energetics of ecosystem.

IMPACT OF BIOSPHERE ON THE ENVIRONMELNT

The entire world is basically divided into abiotic and biotic components.The abiotic world includes atmosphere (air), lithosphere (soil) and hydrosphere (water). The biotic world is made up of living organisms like plants, animals and micro-organisms. All the three sub-divisions of abiotic world represent the global components of world ecosystem. They exchange the matter with each other and eliminate their wastes.Their bodies are rendered into the inorganic molecules once again. Thus, there occurs a recirculation of materials. The biosphere is that part where the life exists and it creates impact on the environment seriously due to the activities of the biotic components.

Biosphere is also referred as ecosphere where the biochemical system is capable of capturing, convecting, storing and utilizing the solar energy. In the cyclic process of life, many elements are shared from a common global pool and are converted from inorganic to organic forms and reach back to the pool again. The entire biosphere has a self-regulatory system with internal checks and balances. It has developed a remarkable degree of homeostasis and ecological control within its various components. Thus, the environment influences the biosphere and biosphere exerts impact on the environment through the process of recycling of materials.

QUESTIONS

1. Give an account of pond ecosystem.
2. Describe universal model of energy flow.
3. Define food chains and explain them in detail.
4. Give an account of ecological pyramids.
5. Write short notes on:
   A. Biosphere

B. Food web
C. Y-shaped energy flow model
D. Ecological pyramids
E. Components of ecosystems
F. Food chains

BIOGEOCHEMICAL CYCLES

Life on the earth is inextricably linked with climate through a variety of interacting cycles and feedback loops. Recently, there is an increased awareness in the human activities *viz.*, deforestation and fossile fuels burning, which directly or indirectly modified the biogeochemical and physical processes involved in determining the earth's climate. These changes can disturb our ecosystems. Besides helping, they also maintain relative climate stability and a self cleansing, protection of earth from ultraviolet rays radiating from the sun and regulation of nutrient cycling.

As the earth is a closed system of matter except a very small quantity of cosmic debris that enters into the earth's atmosphere. It means that all the elements needed for the structural and chemical processes of life, are present in the earth crust when it was formed billions of years ago. This matter is continuously cycled through earth's system, the atmosphere, hydrosphere, biosphere and lithosphere. The time span ranges from a few days to millions of years. These cycles are called biogeochemical cycles because they include a variety of biological, geological and chemical processes.

The elemental cycles run through ecosystems, organisms, air, water, soil and elements are cycled continuously. Many of them are trace elements. Other

elements include carbon, nitrogen, oxygen, hydrogen, sulphur and phosphorus which form the major component of all biological life. In the body of human being the percentage of carbon and oxygen is 80%. These elements are the key components of life and they must be available for the biological processes. The nitrogen (N_2) is abundant in the atmosphere, whereas, the carbon (C) is relatively rare in the earth crust. The biogeochemical cycles transport and store these important elements, so that they can be used by the living organisms. Each biogeochemical cycle takes different pathways and has various reservoirs or storage places where these elements may restored for a short or long duration. The rate of cycling varies in their chemical, biological and geological processes. Some molecules are recycled quickly, depending upon the pathways. How fast substances can be cycled depend upon their chemical reactivity and the gaseous phase allows the molecules to transport quickly. Phosphorus has no gaseous phase and is in inactive condition. It is stored in large amount in the sediments of ocean or earth crust and recycled back to the surface after long duration.

Human activities accelerate the biogeochemical cycles when the elements are extracted from their reservoirs or sources and deposited back into the environment. According to the data available, increased global release of carbon through human activities from one billion tonnes per year during 1940 to 8 billion tons per year in 2008. About half of this extra carbon is taken up by plants and the ocean, while the other half remains in the atmosphere. Besides carbon cycle, human activities have altered the nitrogen and phosphorus cycles by adding these elements into the croplands as fertilizers. Scientists are trying to findout all the varoius pathways and flows each of the biogeochemical cycle under goes and to understand how human activities affect these cycles. There are many phenomena that the scientists are just begining to investigate. Satellite technology has revealed that new information about

interactions between the oceans and the atmosphere that contribute to the knowledge about the carbon cycle, but still there are many unanswered questions.

BIOGEOCHEMICAL CYCLES IN NATURE

The most well known and important biogeochemical cycles include carbon cycle, nitrogen cycle, oxygen cycle, phosporus cycle, sulphur cycle and water cycle. These biogeochemical are always involved in state of equilibrium, which means balancing cycling of elements between compartments. However, the overall balance may involve compartments distributed on the global scale. The biogeochemical cycles of particular interest in the environment are (i). Nitrogen cycle, (ii). Carbon cycle, (iii). Oxygen cycle, (iv). Phosphorus cycle, (v). Sulphur cycle, (vi). Water cycle, and (vii). Hydrogen cycle.

1. Nitrogen cycle

The nitrogen cycle is a more complicated biogeochemical cycle through the living and non-living parts. Nitrogen is a very important element in proteins and nucleic acids. It is present in amino acids that make the proteins and in nucleic acids *viz.*, DNA and RNA, it is present as nirtogenous bases. The largest reservoir of nitrogen is atmosphere whose percentage of nitrogen is 78. Nitrogen gas is fixed through the process of nitrogen fixation. The fixed-nitrogen combines with oxygen and forms nitrates (NO_3). These nitrates can be used by plants and animals. Nitrogen can be fixed either by lighting, industrial methods like fertilizer manufacture, nitrogen-fixing bacteria in the soil and in the root of legumes (*e.g.*, *Rhizobium*). The nitrogen fixing bacteria use certain enzymes that are capable of fixing nitrogen gas into nitrates. The nitrogen fixing bactoria include free living bacteria in the soil, symbiotic bacteria and also cynobacteria or blue-green algae in the water.

After being used by plants and animals, nitrogen is then disposed in the form of decaying matter and wastes. Detrivores and decomposers decompose the dead plants and animals and release nitrogen in the atmosphere. This nitrogen is changed into ammmonia (NH_3). The ammonia is toxic and cannot be used by plants or animals but nitrite bacteria present in the soil take ammonia and convert it into nitrite *i.e.*, nitrogen with two oxygen atoms (NO_2). Nitrite is again not used by plants and animals. Nitrite bacteria change the nitrites again back into nitrates which is usable by plants and animals. Some nitrates are also converted back into nitrogen gas through the process of denitrification. In this way, the nitrogen cycle completes in the nature. It may be concluded that the nitrogen cycle involves nitrogen fixation, nitrification, assimilation, ammonification and denitrification (Fig. 4.1).

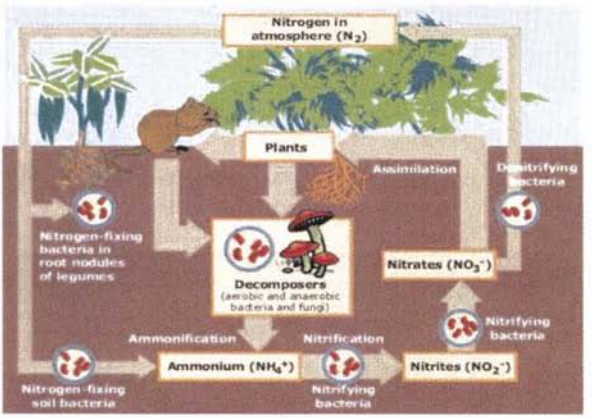


Fig. 4.1: Nitrogen cycle

The disruption of the nitrogen cycle by human activity plays an important role in a wide range of environmental problems ranging from the production of troposphere (lower atmosphere) smog to the perturbation of stratospheric ozone and the contamination of groundwater. For instance, Nitrous oxide, a green house gas like carbon dioxide and water vapours that trap near the earth's surface and form

nitric acid. It also destroys stratospheric ozone. This nitrous oxide is broken down by ultra-violet rays into nitrogen oxide (NO_2) and nitric oxide (NO), which reduce ozone. Nitrogen oxides are chemically transformed back either into N_2 or nitrate or nitrite compounds, which may be used by plants. Nitrate rain is acidic and can cause ecological problems as well as can serve as a fertilizer to vegetation.

2. Carbon cycle

Carbon is a fundamental building block of the life. The life on the earth is comprised of carbon based life forms. Carbon also cycles through the oceans and the biosphere over a short- and long-term time scales. The carbon cycle occurs over days, weeks, months and years and it involves the absorption, conversion, and respiration of carbon by living organisms. Thus, the carbon cycle is the biogeochemical cycle by which carbon is exchanged between the biosphere, geosphere, hydrosphere and the atmosphere of the earth (Fig. 4.2).

The carbon cycle ususally has 4 major reservoirs, interconnected by the pathways of exchange. These are: atmosphere, biosphere, oceans and sediments.

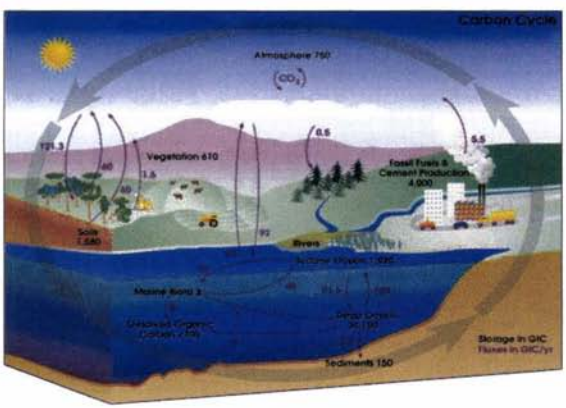


Fig. 4.2: Carbon cycle

1. **Atmosphere:** In atmosphere, the carbon exists as gas, carbon dioxide. Its percentage is 0.04 in the atmosphere, but it plays an important role in supporting the life. Other gases containing carbon are methane (CH_4) and chloroflourocarbons. The overall atmospheric concentration of these greenhouse gases has been increasing in the recent years and it results into the contribution to the global warming. Carbon is taken from the atmosphere as enumerated here.

    1. Through the process of photosynthesis, plants convert carbon dioxide into carbohydrates and release oxygen in the process. This process is prolific in relatively new forests where the growth of trees is rapid.
    2. Forests stores 80% carbon in their body and 73% in the soil.
    3. At the surface of oceans, the sea-water becomes cooler and more carbonic acid (HCO_3) is formed as the CO_2 becomes more soluble.
    4. The upper surface of ocean has high biological productivity in which organisms reduced carbon to the tissues or carbonates to hard body parts *viz.*, shells and tests. These are oxidised, redissolved and which result into downward flow of carbon.
    5. By the weathering of silicate rocks, the carbonic acid reacts with it and produces bicarbonate ions. These ions are carried to the oceans and are converted into carbonates. Weathering does not move the carbon into a reservoir from which it can readily escape into the atmosphere.

Carbon can be released back into the atmosphere in several ways as follows:

(i) Through the process of respiration by animals and plants.

(ii) Through the combustion of organic nutrients *viz.*, burning of fossil fuels like coal, petroleum and natural gases..

(iii) Through the production of cement. CO_2 is released when lime stone ($CaCO_3$) is heated and produces CaO, a component of cement.

(iv) The surface of ocean becomes warmer, which dissolves CO_2 and releases back into the atmosphere.

(v) Volcanic eruptions and metamorphism release gases into the atmosphere. Volcanic gases are water vapours, CO_2 and SO_2.

(vi) Crops and forests absorb a lot of carbon through the process of photosynthesis.

2. **Biosphere:** Cabon is an essential part of life on the earth. It plays an important role in the structure, biochemistry, and nutrition of all living cells. Around 1900 gigatons of carbon is present in the biosphere.

(i) Autotrophic organisms like green plants utilize the atmospheric carbon dioxide through the process of photosynthesis. A small number of autotrophs exploit chemical energy through the process of chemosynthesis. The most important autotrophs for the carbon cycle are trees in the forests, and phytoplankton in the oceans. The photosynthesis takes place as follows:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

(ii) The carbon is transferred into the biosphere through the heterotrophs. This includes, the uptake of dead organic matter by fungi and bacteria for decomposition.

(iii) Most of the carbon released in the biosphere through the process of respiration.

(iv) The burning of biomass *viz.*, wood that burns, forest fires, transfers the substantial amount of carbon to the atmosphere.

(v) Cabon is also circulated in the biosphere through dead organic matter.

(vi) Much of the carbon remains in the deep ocean *e.g.*, the larvacean mucus houses "sinkers" delivering cabon to the deep ocean.

Carbon storage in the biosphere is influenced by a number of processes. It can be stored for hundreds of years in trees and thousand of years in the soil. Changes in these long-term pools may affect the global climate change.

3. **Oceans:** In oceans, around 36,000 gigatons of carbon is present in the form of bicarbonates. Inorganic carbon is important in its reaction within the water. This carbon exchange controls the pH of the ocean and also as a source or sink for carbon. Carbon is readily exchanged between the atmosphere and ocean. In the regions of oceanic upwelling, carbon dioxide is released into the atmosphere and the region of downwelling transfer the carbon dioxide from the atmosphere to the ocean, it undergoes a series of reactions such as,

$$CO_2 \text{ (atmospheric)} \rightarrow CO_2 \text{ (dissolved)}$$

$$CO_2 \text{ (dissolved)} + H_2O \rightarrow H_2CO_3$$

1st ionization:

$$H_2CO_3 \rightarrow H^+ + HCO_3 \text{ (biocarbonate ions)}$$

2nd ionization:

$$HCO_3 \rightarrow H^+ + CO_3 \text{ (carbonate ions)}$$

This set of reactions has its own equilibrium coefficient which determines the inorganic carbon in ocean. In the ocean, the biocarbonate combines with calcium and forms limestone. It is the largest reservoir of carbon in the carbon

cycle. The calcium formed by the weathering of calcium silicate rocks which causes the silicon in the rocks to combine with oxygen and forms sand or quartz (SiO_2), making calcium ions available to form limestone.

3. Oxygen cycle

Oxygen is an important constituent of the planet Earth, without which nobody can survive. In nature, there is also a biogeochemical cycle of this gas. The percentage of oxygen in the atmosphere is 21%. The cyclic movement of oxygen continuing within and between its three main reservoirs *viz.*, the atmosphere (air), the biosphere (living things) and the lithosphere (earth-crust). Such type of biogeochemical cycle is referred to as oxygen cycle (Fig. 4.3). The main driving factor of oxygen cycle is the process of photosynthesis.

The main source of oxygen within the biosphere and atmosphere is photosynthesis, which breaks down carbon dioxide and water to create sugar and oxygen.

$$6CO_2 + 6H_2O + \text{Energy} \rightarrow C_6H_{12}O_5 + 6O_2$$

Additional source of atmospheric oxygen is photolysis where high energy ultraviolet radiations break down the

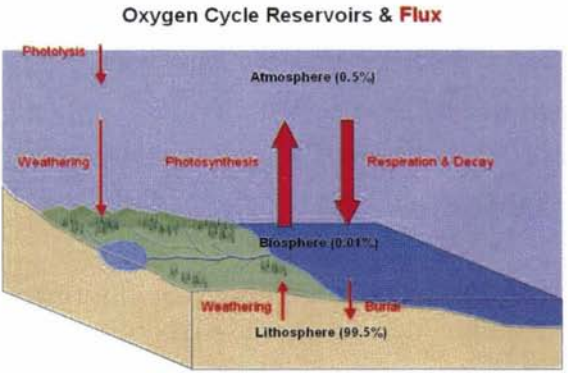


Fig. 4.3: Oxygen cycle

atmospheric water and nitrite into the component atoms. The free hydrogen and nitrogen atoms escapes into the space and O_2 is added to the atmosphere. The chemical reactions are as follows:

$$2\ H_2O + \text{Energy} \rightarrow 4H + O_2$$
$$2\ N_2O + \text{Energy} \rightarrow 4N + O_2$$

The main way of oxygen lost from the atmosphere is through respiration and decay. Oxygen is also cycled between the biosphere and lithosphere. Marine organisms in the biosphere create calcium carbonate shell material ($CaCO_3$) that is rich in oxygen. When the organism dies, its shells are deposited on the shallow sea floor and buried over time to create the limestone rock of the lithosphere. Because of weathering process initiated by the organisms can also release oxygen from the lithosphere. Plants and animals extract nutrient minerals from the rocks and release oxygen. The presence of atmospheric oxygen leads to the formation of ozone layer within the stratosphere. The ozone layer absorbs harmful ultraviolet radiations.

$$O_2 + \text{UV Energy} \rightarrow 2\ O$$
$$O + O_2 \rightarrow O_3$$

Thus, the oxygen cycle completes in the atmosphere, biosphere and the lithosphere. We have studied nitrogen, carbon and oxygen cycles which are gaseous type of biogeochemical cycles in the nature.

Now, we will see sedimentary type of biogeochemical cycles including phosphorus and sulphur cycles.

4. Phosphorus cycle

Phosphorus is an important element for all living organisms. As phosphate (PO_4) makes an important part of the structural framework that holds DNA and RNA together. Phosphates are also a critical components of ATP as they serve as an energy release component for the

organisms to use building proteins or contracting muscles like calcium. Phosphorous are important to vertebrates. In human body, approximately 80% phosphorus is found in teeth and bones.

A phosphorus cycle (Fig. 4.4) is the biogeochemical cycle that describes the movement of phosphorus through lithosphere, hydrosphere and biosphere. The atmosphere does not play a significant role in the movement of the phosphorus because phosphorus and phosphorus-based compounds are usually solid and found in the earth crust.

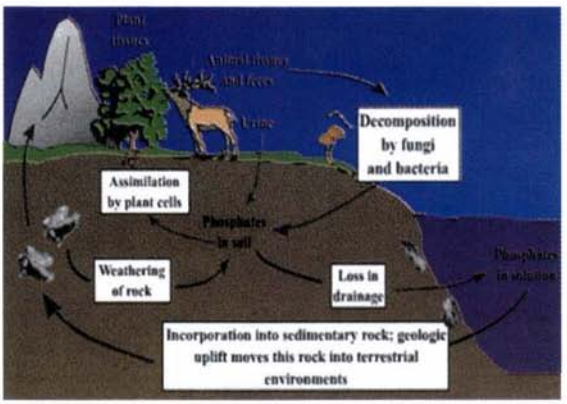

Decomposition by fungi and bacteria
Assimilation by plant cells
Phosphates in soil
Weathering of rock
Loss in drainage
Incorporation into sedimentary rock; geologic uplift moves this rock into terrestrial environments

Fig. 4.4: Phosphorus cycle

Phosphorus cycle is a sedimentary type biogeochemical cycle. In phosphorus cycle, there is no gaseous phase as compared to other biogeochemical cycle, although the small amount of phosphoric acid (H_3PO_4) may make their way into the atmosphere, contributing to the acid rain. Water, carbon, nitrogen and sulphur all include at least one phase in which the element is in its gaseous state. Very little phosphorus circulates in the atmosphere. The largest reservoir of phosphorus is the sedimentary rocks. In these sedimentary rocks, the phosphorus cycle begins. When it rains, the phosphorus is removed from

the rocks through the process of weathering and is distributed throughout both the soil and water. Plants take up the phosphate ions from the soil. The phosphates then move from plants when a herbivore that eats plants and a carnivore that eats herbivores. The phosphates are absorbed by the animal tissues through the consumption and returned to the soil through the excretion of urine and faeces, as well as from the final decompositon of dead plants and animal.

The same process occurs in the aquatic ecosystems. As phosphorus is not highly soluble, it mostly reaches water by travelling with runoff soil particles. Phosphates also enters into the waterways through fertilizer runoff, sewage seepage, natural mineral deposites and wastes from other industrial processes. This phosphorus settles down in the oceanic floor and lake's bottom. As sediments are stirred up, the phosphates re-enters into the phosphorus cycle, but they are more commonly made available to the aquatic organisms through erosion. Water plants take up the water borne phosphate which then travels through successive stages of the aquatic food chain. Thus, phosphorus cycle is one of the longest cycle and takes a long time to move from sediments to the living organisms and back to the sediments.

Phosphate stimulates the growth of phytoplankton and plants. Excess growth of these tends to consume large amount of dissolved oxygen, potentially suffocating fish and other marine animals, which results into the eutrophication. Human can alter the phosphorus cycle in many ways including the cutting of tropical rain forests and through the use of agricultural fertilizers. The use of laundary detergents also contribute to the concentration of phosphates in rivers, lakes and streams significantly, but now most detergents no longer include phosphorus as an ingredient.

5. Sulphur cycle

Sulphur is one of the constituent of many proteins, vitamins and hormones. It is cycled as in other biogeochemical cycles. Sulphur plays a critical role in both climate and in the health of various ecosystems. In earth, sulphur is stored in rocks and minerals including sulphate salt buried deep within oceanic sediments (Fig. 4.5).

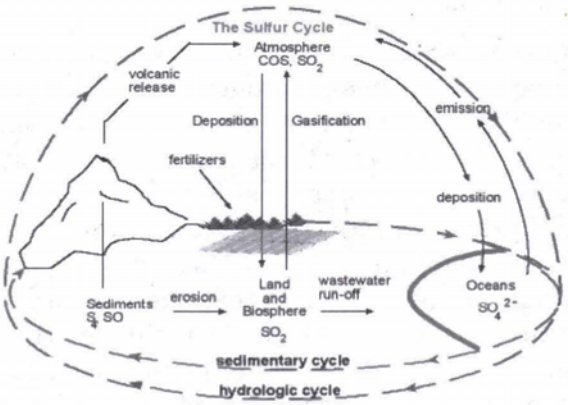


Fig. 4.5: Sulphur cycle

The essential steps of the sulphur cycle are as follows:

1. Mineralization of organic sulphur into the inorganic form, hydrogen sulphide (H_2S).
2. Oxidation of sulphide and elemental sulphur (S) and related compounds to sulphate (SO_4^{2-}).
3. Reduction of sulphate to sulphide.
4. Microbial immobilization of the sulphur compounds and subsequent incorporation into the organic form of sulphur.

The sulphur cycle contains both atmospheric and terrestrial processes. In terrestrial processes, the cycle begin with the weathering of rocks, releasing the stored

sulphur. The sulphur then comes into contact with air where it is converted into sulphate (SO_4). The sulphate is taken up by plants and micro-organisms and is converted into organic forms. Animals consume this organic sulphur through their food and thus the sulphur enters into the food chain. When the organism dies, it decomposes and again sulphur is released in the form of sulphate and some enters into the tissues of micro-organisms.

There are also a variety of natural sources which release sulphur directly into the atmosphere including volcanic eruptions, the breakdown of organic matter in swamps and tidal flats, and the evaporation of water. A continuous loss of sulphur from terrestrial ecosystem occurs through runoff and drainage into lakes and streams, and eventually to the oceans. Sulphur also enters into the oceans through fallout from the earth's atmosphere. Within the ocean, some sulphur enters into the cycle through marine communities, moving through the food chain. A portion of this sulphur is emitted back into the atmosphere from sea spray. The remaining sulphur is lost into the ocean depth which results into its blockade in most marine sediments.

Human activities also contribute to the amount of sulphur that enters into the atmosphere, through the burning of fossil fuels and the processing of metals. However, sulphur dioxide and sulphate arosols absorb ultraviolet radiations, creating cloud cover that cools cities and may offset global warming caused by the green house effect. The exact amount of this offset is a big question and the scientists are attempting to answer this question.

6. Water cycle

Earth's water is always is in movement, and this movement of water is water cycle, also known as the hydrological

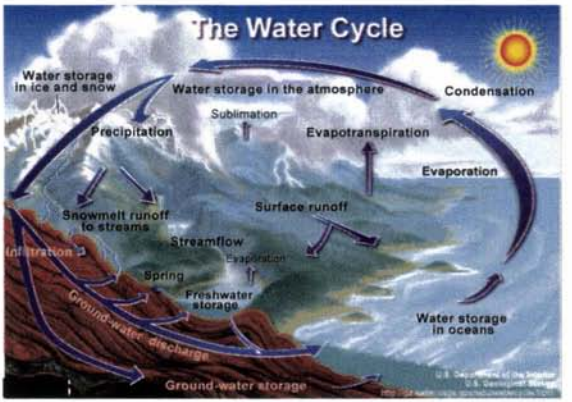


Fig. 4.6: Water cycle

cycle, which describes the continuous movement of water on, above and below the surface of earth. Water cycle has no beginning or end point, it is contiuously cycling. Water can change its states among liquid, vapour (gas) and ice (solid) at various stages in the water cycle. However, the balance of water on earth remains fairly constant over the time, individual water molecules can come and go in a hurry, but there is always the same amount of water on the surface of earth (Fig. 4.6).

Most of the life on the earth is also primarily composed of water including our cells, plants and animals. Vast quantity of water is also cycled through the atmosphere, ocean, land, and biosphere over both short- and long-time scales. Such a grand cycling of water is called as hydrological cycle or water cycle. The water cycle is dominated by the oceans where 96% of the water on the earth is found and 86% of global evaporation occurs.

When rains and other precipitation falls on the land, some of it runs off into the surface water, lakes and streams. Much of it seeps into the ground. This process is called as infilteration. Water that is not absorbed into the soil flows across the landscape into the rivers, lakes,

streams and eventually to the oceans while some runoff waters originates from precipitation, melting of snow or ice and is called as melt water runoff. The area where precipitation reaches, the land drains into a common body of water is called as 'watershed'. The communities try to improve the quality of their watersheds.

The surface water, rather it seeps into the soil and flows through the surface soil and some water gets evaporated by the sunlight through the process of evaporation. However, all the water returns into the atmosphere through the process of evaporation. Sometimes water gets evaporated from the surface of plants and is called transpiration. The process of evaporation and transpiration is commonly called as evapo-transpiration.

The process of high water vapour is converted back into liquid, is called as condensation. The most familier example of this is the formation of dew drops on the blades of grass or on the outside of a cold glass. As water vapours move upwards in the atmosphere, it cools. This process is called condensation. The droplets formed from the atmospheric condensation gathered together to form big drops and as a result of their gravitation pull they form the clouds. Depending on the temperature of the surrounding air, this cloud moisture will take either frozen or in liquid form.

Water in the atmosphere, after condensing, forms clouds and returns to the earth through precipitation. Water is stored on the earth in the form of lake, reservoirs for a period of time and again it returns into the at mosphere through the process of evaporation. Thus, the water cycle will continue till the end of earth.

7. Hydrogen cycle

Hydrogen is one of the constituent of water. It is recycled as other elements through the biogeochemical cycles. It is

actively involved with other cycles like carbon cycle, nitrogen cycle, sulphur cycle and oxygen cycle as well. The hydrogen cycle is a cycle in which solar energy burns up the sea water and releases the hydrogen which combines with oxygen and forms water vapour that returns to the sea. In this way, the hydrogen cycle is completed in nature.

QUESTIONS

1. Define Biogeochemical cycles. Explain nitrogen cycle.
2. What do you understand by the Biogeochemical cycles?
3. Give the significance of Biogeochemical cycles.
4. Explain the following cycles:
   A. Carbon cycle
   B. Phosphorus cycle
   C. Sulphur cycle
   D. Water cycle

5

POPULATION ECOLOGY

The study of a population is very significant as the biotic communities are made up of several population groups and cannot be understood without study of its dynamics and relationships. A population must adjust with the environment. Population ecology is a major sub-field of ecology that deals with the dynamics of species population and how these populations interact with the environment. The word population is derived from the Latin word 'populus' which means 'people' and 'logous' means 'study'. Thus, the population is a group of people occupying a particular space. Population is sub-divided into demes or local populations, which are the groups of inter breeding organisms. In population ecology, we study the number of organisms and causes of their abundance and distribution. The development in the field of population ecology owes much to the science of demography and the use of acturial life-tables. Population ecology also plays an important role in the development of population viability analysis (PVA) which make it possible to predict the long-term probability of a species persisting in a given habitat *e.g.*, a national park. Population ecology also provides many interesting problems for the mathematicians and statisticians which work mainly in the study of population dynamics.

CHARACTERISITCS OF A POPULATION

A population has several specific characteristics including population density, natality, mortality, age distribution, population growth etc. which are explained as follows:

1. Population density

Population density refers to the number of peoples per square kilometer of the land area. Population density is a common biological measurement and often used by conservationists as a measure of the population. Low density population may causes extinction and also leads to reduced fertility, which is mainly due to increased problems in locating mates and increased inbreeding. Different species have different expected densities. Low densities may be associated with specialized mate location adaptation *viz.*, specialized pollinators which are found in the orchid family.

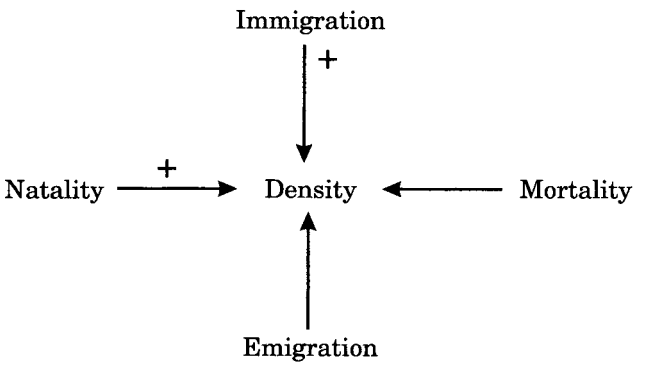
As the human population density is the number of peoples per unit of area, it may be calculated for a city, country, territory or world. Suppose the world population is 6.6 billion human beings and earth's area is 510 million square kilometers. Therefore, the worldwide human population density will be 6.6 billion / 510 million = 13 per km^3. Considering that human being live on land, which forms 150 million km^2 of the earth. This density rises with the population growth. It also includes all continental and island area including Antartica. Several highest density territories in the world are very large cities, states, microstates, micronations or dependencies. Cities with exceptionally high population densities are often consided to be over populated. Most of the largest density populated cities are in southern and eastern Asia, though Cairo and Lagoes in Africa also fall into this category.

Population density can be measured in various ways. The arithemetic density is the most common way of

measuring population density. There are also several other methods which have been developed to provide more accurate measures of population density over a specific area. Some of the important methods are as follows:

1. Arithemetic density: The total number of peoples/ area of land measured in km^2.
2. Urban density: The number of peoples inhabiting an urban area/the total area of urban land.
3. Agricultural density: The total rural population/ amount of agricultural land.
4. Residential density: The number of peoples living in an urban area/the area of residential land etc.

According to Kreb (1994), 4 process, *viz.*, natality, mortality, immigration and emigration are the primary parameters that affect the population density as shown below:



2. Natality

Natality is a second major characteristics of a population. Population increases only due to the natality. Natality is nothing but the birth rate and it is an expression of the production of new individual by birth, hatching, germination or by fission. Natality rate is expressed by the number of organisms born per female per unit of time. As a general rule, if the population density is low, the birth

rate is also low but if the population density is high, the birth rate is also relatively high. The reasons for low density is inadequate nutrition, or the physiological or psychological aberrations associated with the over population. When the population density is optimum, the rate of population is also maximum. Natality can be calculated by using the following formula:

$$\text{Natality (b)} = \frac{\text{No. of births per unit time}}{\text{Average population}}$$

Thus, natality (birth rate) increases the population of a community, country or world.

3. Mortality

The mortality is the third important characteristics of population. Mortality is just opposite to the natality. Mortality is the death rate per unit time in a population. The mortality expresses the loss of individuals per unit time. The mortality rate is high at very high density of population. Mortality is quite high at very low density population because the number of individuals of a given species are often better able to survive during a period of stress than a single individual. The death rate varies among the species and it is correlated with rate of reproduction *i.e.*, natality. The mortality of a species is influenced by a number of factors *viz.*, destruction of nests, eggs or young ones, wind, floods, predators, accidents etc. When more young ones are born in a habitat, then the surplus may either die or leave the area. The reason of this is the number of survivors is more important than the number dying. Mortality rate expresses the percentage of individuals during given period of time. The mortality rate in many species varies from one age level to another. Mortality varies positively with age in most of the organisms.

4. Age distribution

It is an important characteristics of a population as it influences both the natality and mortality. Usually mortality varies with the period of life span. Similarly, natality is restricted to certain age groups *e.g.*, the middle age groups in the higher animals. The age distribution of a population may remain constant or may change throughout the generation period. The population age distribution is closely related with the growth rate of the population and it can be used for estimating whether population is expanding or contracting. Beside this, the ratio of various age groups determines the current reproductive status of the population and also expects the future of the population. Generally, in a rapidly expanding population there is a large proportion of young ones, and in declining population, a large proportion of old individuals are occurring.

Boden Heimer (1985) studied the various age groups of a population and classified them into three categories *viz.*, pre-reproductive age, reproductive age and post-reproductive age. In natural population, the age structure is constantly changing. In rapidly growing populations *e.g.*, bacteria, yeast and housefly, the rate of birth is high and the population growth may be exponential. Under such conditions, each successive generation will be more numerous than the predicted one and results into a pyramid-shaped age structure. In a stable population, a bell shaped-age structure will be formed because the pre-reproductive and reproductive age groups become more or less equal in size and the post-reproductive group remains the smallest. In a declining population, an urn-shaped age structure will be formed which indicates the smallest size of pre-reproductive category or young individuals. According to Barclay (1958), in a human population there are difference in mortality rate which have little effect on age composition and the birth rate have largest effect on the age structure (Fig. 5.1).

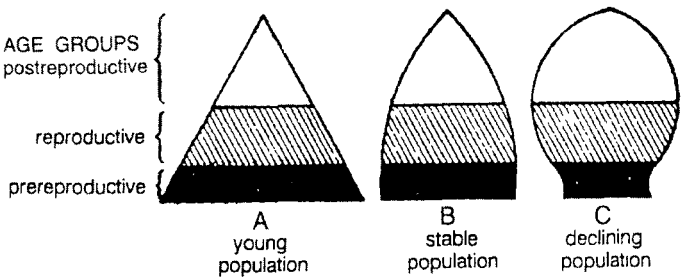


Fig. 5.1: Different age pyramids

5. Population size

Population size is the number of individual organisms in a population and it is denoted by 'N'. The effective population size (Ne) is defined as, 'the number of breeding individuals in an idealized population that shows the same amount of dispersion of allele frequencies under random genetic drift or the same amount of inbreeding as population under consideration'. 'Ne' is usually less than 'N' (the absolute population size) and this has important application in conservation genetics. Small sized populations increase genetic drift and the over population may indicates that the population of any species of animal may exceed the carrying capacity of its ecological niche.

6. Population growth

There are several features of a population, which we have already studied. Beside these, there is also one most important characteristics of a population and it is population growth. Population growth is the increase in number of individuals per unit time. By measuring the size or density of a given population from time to time we can obtain important information regarding its rate of increase and can also predict future of its size. For measuring the growth of a population of a particular species in the laboratory, for example, bacteria or yeast cells, we first transfer a relatively small number of the given

individuals to a flask containing appropriate nutrient solution and proceed to measure the population increase over a desirable period of few days. This we call population growth rate.

In a population, population growth rate (PGR) is the fractional rate at which the number of individuals in a population increase. Specially PGR ordinarily refers to the change in population over a unit time period, often expressed as a percentage of the number of individuals in the population at the begining of that period. It can be expressed as,

$$\text{Population growth rate} = \frac{\text{Population growth rate end of period} - \text{Population at the begining of the period}}{\text{Population at the begining of the period}}$$

The population growth ratio express as,

$$\text{Growth ratio} = \text{Growth rate} \times 100\%$$

A positive growth ratio (rate) indicates that the population is increasing while a negative growth ratio (or rate) indicates population decline. However, growth rate may be zero, even when there are significant changes in the birth rates, death rates, immigration rates and age distribution. The human population growth can exceed the carrying capacity of an area or environment and the result ends with over population. Globally, the growth rate of the human population has slowed down a little since 1980's. Although the last one hundred years have seen a rapid increase in population due to medical advances and massive increase in agriculatural productivity made possible by the green revolution. In some countries, there is a negative population growth (*i.e.*, net decrease in population over time), especially in Central and Eastern Europe (mainly due to the fertility rate) and Southern Africa (due to the high number of HIV - related deaths). Within the next decade, Japan and some countries in Western Europe are also expected to encounter

the negative population growth due to sub-replacement fertility rates.

7. Carrying capacity

In a supportable population of an organism, with the food, habitat, water and other necessities available within an ecosystem is referred as ecosystem's carrying capacity for that organism. For the human population, some times sanitation and medical care is also considered as a part of the necessary infrastructure. As the population density increases, birth rate decreases and death rate typically increases. Difference between the birth rate and death rate is the 'natural increase'. The carrying capacity could support a positive natural increase or could require a negative natural increase. Carrying capacity is, thus, the number of individuals in an environment which can be supported without significant negative impacts to the given organism and its environment. Scientists have reported that below carrying capacity, the population typically increases, while above, typically decreases. Population size decreases above carrying capacity due to a range of factors depending on the species concerned but can include insufficient space, food supply or sunlight. The carrying capacity of an environment may vary for different species and may change over time due to a variety of factors including food availability, water supply, environmental conditions and living space.

It is possible for a species to exceed its carrying capacity temporarily. Population variance occurs as a part of the natural selection process but may occur more dramatically in some instances. Due to a variety of factors and determinants of carrying capacity may lag behind another *e.g.*, a waste product of a species may build up to toxic level more slowly than the food supply is exhausted. The result is a fluctuation in the population around the equilibrium point which always is statistically significant.

These fluctuations increase or decrease in population until either the population returns to the original equilibrium point or new one is established. These fluctuations may be more devastating for an ecosystem as compared to gradual population corrections.

Not all social scientists and demographers are convinced of an eminent carrying capacity crisis for human beings. If agricultural innovations could increase with population density, carrying capacity might also increase in some areas, averting a crisis there. However, Africa is still subject to desertification and other effects suggesting that population may be outpacing agricultural development. Neverthless, there have been concerns that carrying capacity has been surpassed in 2008 due to a combination of soaring prices for commodities and food.

8. Population genetics and genetic diversity

The study of the allele frequency distribution and changes under the influence of the four evolutionary forces *viz.*, natural selection, genetic drift, mutation and gene flow is known as population genetics. Population genetics takes the account of population sub-division and population structure in space. Population genetics also explains the phenomenon of adaptation and speciation. Population genetics is a vital ingredient in the modern evolutionary synthesis. S. Wright, J.B.S. Haldane and R.A. Fisher had laid the foundation of population genetics.

The academic field of population genetics including several hypothesis regarding the genetic diversity. Genetic diversity is a level of biodiversity that refers to the total number of genetic characteristics in the genetic make up of a species. The neutral theory of evolution proposes that diversity is the result of the accumulation of neutral substitutes. Diversifying selection is the hypothesis that two sub-populations of a species live in different

environments that select for different alleles at a particular locus. This may occur, if a species has a large range relative to the mobility of individuals within it. Frequency dependent selection is the hypothesis that an allele becomes more common, it becomes less fit.

The Hardy-Weinberg principle states that both allele and genotype frequencies in a population remain constant, that is, they are in equilibrium from generation to generation unless specific disturbing influences are introduced. Those disturbing influences include non-random mating, mutations, selection, limited population size, random genetic drift and gene flow. It is important to understand that outside the laboratory, one or more of these "disturbing influences" are always in effect. That is, Hardy Weinberg equilibrium is impossible in nature. Genetic equilibrium is an ideal state that provides a base line to measure genetic change. Static allele frequencies in a population across generations assume: random mating, no mutation (the alleles don't change), no migration or emigration (no exchange of alleles between populations), infinitely large population size, and no selective pressure for or against any traits. This concept is also known by a variety of names: Hardy-Weinberg equilibrium (HWE) or Hardy-Weinberg law. It was named after G. H. Hardy and Wilhelm Weinberg.

The genetic diversity and biodiversity depend upon each other. According to Dr. Richard Lankauof, if any one type of diversity (genetic diversity or biodiversity) is removed from the system, the cycle can break down and the community becomes dominated by a single species. Genetic diversity plays a huge important role in the survival and adaptability of a species. A slight gene variations are necessary for it to adapt and survive. A species has a large degree of genetic diversity among its individuals will have more variations from which to choose the most fitting allele. Species that have a very little genetic

variations are at great risk. A very little gene variations within the species, healthy reproductive process become increasingly difficult and offsprings deal the problem of inbreeding.

Genetic diversity of a population can be assessed by some simple measures as following:

1. Genetic diversity is the proportion of polymorphic loci across the genome.
2. Heterozygosity is the mean number of individual with polymorphic loci.
3. Alleles per locus are also used to demonstrate variability.

The natural world has several ways of preserving or increasing genetic diversity. For example, Cheetah is an endangered species. Extremely low genetic diversity and resulting poor sperm quality has made breeding and survivorship difficult for Cheetah. Only about 5% of Cheetah make it to adulthood.

FACTORS AFFECTING THE POPULATION

Many groups of animals and plants are provided with the unique and intrinsic self regulatory mechanism *viz.*, failure of reproduction and self inflicted mortality for controlling the size of population. As we studied, population grows when natality exceeds mortality, and declines when mortality exceeds natality. Thus, there are two factors which regulate or effect the population of organisms. These are: Density independent and Density dependent factors.

1. Density independent factors

These are the extrinsic factors which tend to regulate the density of a population under different conditions, appearing to act on the population and inflict the loss of individuals irrespective of the population density.

Variations in space, favourable weather and food are the density independent factors. These environmental factors influence the negativity or positivity of all the individuals of a population irrespective of a density.

2. Density dependent factors

These are intrinsic or biotic factors and they depend upon the co-action between individuals within the same population or between populations of different species. Some of the density dependent factors are competiton, reproductivity, predation, emigration and diseases. These factors vary from species to species. Generally, the population fluctuations controlled by extrinsic factors (density dependent factors) tends to be irregular and correlated with the variation in one or more major physical limiting factors *viz.*, temperature, food, water etc. The fluctuations of populations controlled by intrinsic factors (density dependent factors) exhibit regularity in the population cycles. Population cycles alternately errupt and subside in more or less uniform manner between high and low levels of density. Different animals exhibit population cycles at different times. The best established cycles of population density of fluctuation are those of periodicity of 3 to 4 years and 9 to 10 years.

QUESTIONS

1. Write an essay on characteristics of a population.
2. What are the factors affecting the population of a community?
3. Explain carrying capacity and genetic diversity.
4. Write short notes on:
   A. Population density
   B. Population size
   C. Population growth

6

ECOLOGICAL DIVISIONS OF INDIA

India is one of the major country in the word. It's geography is diverse in nature, with landscape ranging from snow-capped mountain ranges to deserts, plains, rainforests, hills and plateaus. India has a coastal line of over 7,000 km. Most of the India lies on a pennisula of Southern Asia that protrudes into the Indian Ocean. India is bounded in the south-east by Arabian Sea and in the East and South-East by the Bay of Bengal.

Indo-Gangetic plain occupies northern, central and eastern India while the Deccan plateau includes southern India. In the West of India, there is Thar desert, a rocky and sandy desert. East and North-Eastern border of India consist of a high Himalayan range. The highest part of India is Jammu and Kashmir.

In the north-east border of India, there is a border of Pakistan. To the North border is China and to the east border are Bhutan and Nepal. Myanmar to the East coast and Bangladesh to the East of West Bengal. Srilanka, Maldives and Indonesia are the islands nations of South Asia. When we see India from political point of view, then it is divided into 28 states and seven union territories.

India lies at 8 4' north of equator, 37°6' north latitude and 68°7' and 97°25' East longitude. It is seventh largest

country in the world with a total land area of 3,287,265 square kilometers.

ECOLOGICAL DIVISIONS OF INDIA

Ecologically, India is divided into seven regions *viz.*, Mountains, Indo-Gangetic plains, Thar desert, Highlands, East coast, West coast, and Islands.

1. Mountains

Indian mountains composed of Himalaya, Hindu Kush and Patkai ranges which define the Indian sub-continents. These mountains were formed by the tectonic collision of Indian plates with Eurasian plate before 50 million years ago. These mountain ranges are home to some of the world's tallest mountains and they also act as a barrier to the cold winds. They also create monsoon winds. The river originated in these mountains provide water to the Indo-Gangetic plains. Historically, mountain ranges served as barriers to the invaders. India has seven major mountain ranges *viz.*, Himalayan ranges, Aravali ranges, Vindhya ranges, Satpura ranges, Eastern ghats, Western ghats, Patkai ranges.

I. **Himalayan ranges:** The Himalayan mountain ranges are the world's largest mountain ranges. It forms the India's north-eastern border and separating it from the rest of Asia. The height of Himalaya from the sea level is 2,500 m (8,202 ft.) and it covers the area of approximately 5,00,000 km^2. The Himalayan ranges are spread in Jammu and Kashmir in West and Arunachal Pradesh in East. Himachal Pradesh, Uttarakhand and Sikkim also lies in Himalayan ranges. The peak range of Himalaya is 7,000 m (22,966 ft.) and snow line ranges upto 6,000 m (19,685 ft.) in Sikkim. Kanchanganga, lying on the Sikkim-Nepal border, is the highest

point of the Himalayan ranges and there is a snow fall throughout the year in Himalaya.

II. **Aaravali ranges:** The Aaravali ranges are the oldest mountain ranges in India are running from north-east to south-east across Rajasthan in western India, extending approximately 500 km. The northern end of ranges continues as isolated hills and a rocky ridges into Haryana ending near New Delhi. The highest peak is Mount Abu, rising to 1,722 m (5,650 ft) is close to the border of Gujarat. The Aaravali ranges, are the eroded stub that was once snow-crapped. These ranges join to the two ancient segments *viz.*, Marwar segment to the north-west and Bundelkhand segment to the south-east.

III. **Vindhya ranges:** The Vindhya mountain ranges are located in Central India, covering a distance of 1,050 km. The average height of these hills is 3,000 m (9,843 ft.). It is believed that the Vindhya ranges are created from Aaravali mountains. The western end of this mountain lies in the Eastern Gujarat, near the border of Madhya Pradesh. Northern side almost meeting to Ganga river at Mirzapur.

IV. **Satpura ranges:** The Satpura ranges are also found in the Central India and run across the Maharashtra, Madhya Pradesh and Chhattisgarh. Its distance is 900 km. It is triangular in shape and runs parallel to the Vindhya range. The Narmada river runs in the depression between the Satpura and Vidhya ranges.

V. **Eastern ghats:** The Eastern ghats are the discontinuous ranges of mountains, which have been eroded and cut through by the four major rivers of southern India *viz.*, Godavari, Mahanadi, Krishna and Cauvery. These ranges extend from West Bengal in the north, through Orissa and Andhra Pradesh and Tamilnadu in the south. The height of Eastern

ghats is around 1,000 m (3281 ft.). The eastern ghats meets to the western ghats at Nilgiri hills in Tamilnadu.

VI. **Western ghats:** The western ghats or Sahyadri mountains run along with the western edge of India's Deccan Plateau and separate it from narrow coastal plain along the Arabian sea. The western ranges starts in the south of the Tapti river near Gujarat-Maharashtra border (1,600 km) across the states of Maharashtra, Goa, Karnataka, Kerala, Tamilnadu and go upto almost Southern tips of Indian peninsula. The Anai Mudi in the Kerala is the highest peak in the western ghats.

VII. **Patkai ranges:** The Patkai ranges also known as *'Purwanchal'*. These ranges are created by the tectonic process which has resulted into the formation of Himalayas. These ranges are found on the India's eastern border with Myanmar. The Patkai ranges are conical in shape with steep slopes and deep valleys. There are three hill ranges in Patkai including the Patkai bum, the Garo-Khasi-Jaintia range and the Lushai hills. The Garo-Khasi-Jaintia range is in the Meghalaya. Mawsynram, a village near Cherapunji receiving the highest annual rainfall in the country.

2. Indo-Gangetic plains

These plains are largest flood plains of Ganga-Brahmaputra river system and parallel to the Himalayan ranges. The Indo-Gangetic plains covers an area of 7,00,000 km^2. Major rivers of this system are Ganges and Indus rivers along with their tributaries: Beas, Yamuna, Gomati, Ravi, Chambal, Sutlaj and Chenab. These plains are flat and mostly treelers. The area is also rich in groundwater sources. The major crops grown on the Indo-gangetic plains are rice and wheat along with other crops like maize,

sugarcane and cotton. The Indo-Gangetic plains are the world's most densely populated areas. In the Indo-Gangetic belt, alluvium is formed by the deposition of silt of many rivers. These great plains have been classified into four divisions *viz.*, a. Bhabar belt, b. Terai belt, c. Bangar belt and d. Khadar belt. These Indo-Gangetic plains are of great significance.

3. Thar Desert

It is a great Indian desert. It is a hot desert and forms a significant portion of Western India. The desert is occupied in the Punjab, Haryana, Rajasthan and Gujarat, covering an area of 2,08,110 km^2. The desert is continued in Pakistan. Most of the area of the Thar desert is in Rajasthan *i.e.*, around 61%. Thar desert is rocky with small portion of sand. The origin of the Thar desert is uncertain. According to some geologists, it might have been originated between 4,000 to 10,000 years earlier. The temperature of the Thar desert is above 45°C during the summer and below freezing in the winter. The desert does not receive much rainfall. The annual rainfall in the desert is very low *i.e.*, around 120 mm in west and 375 mm in east. The lack of rainfall is mainly due to the position of desert with respect to the Aaravali mountain ranges.

4. Highlands

The Central highlands are composed of 3 main plateaus *viz.*, I. Deccan plateau, II. Chota Nagpur plateau and III. Malwa plateau.

I. **Deccan plateau:** It lies in the south covering most of the Indian peninsula. It is a largest triangular plateau, bounded by the Vindhya's range in the north and flanked by the Eastern and Western Ghats. The total area of Deccan plateau is 1.9 million km^2. It is mostly flat, with elevations ranging from 300-600 m (1,000 to 2,000 ft.).

The name 'Deccan' is derived from the Sanskrit word, *'dakshina'* which means the 'South'. The Deccan plateau has slope from west to east give rise to several peninsular rivers like Godavari, Narmada, Krishana and Cauvery rivers. This region is mostly semi-arid and much of the Deccan plateau is covered by the thorn scrub forests. The climate of Deccan plateau remains hot during summer and mild during winter season.

II. **Chota Nagpur plateau:** It is located in Eastern India covering most of the Jharkhand as well as some part of Orissa, Bihar and Chhattisgarh. Its area is 65,000 km^2. It is divided into 3 smaller plateaus *viz.*, Ranchi, Hazaribagh and Kodarma plateau. The Ranchi plateau is a largest plateau with an average elevation of 700 m (2,300 ft.). The Chota Nagpur plateau is mostly covered by the deciduous forests and famous for coal and ores.

III. **Malwa plateau:** It is in the west of India. Besides these highlands, the great Indian peninsula, the Kathiawar peninsula in Gujarat is another largest peninsula of India.

5. Eastern ghats

The east coastal area is a widely stretch of land, lying between the Eastern ghats and the Bay of Bengal. A major portion of these coasts form the delta's of many rivers in India including the Mahanadi, Godavari, Cauvery and Krishna rivers. The annual rain fall is 1,000 mm (40 inches) to 3,000 mm (120 inches). The width of Eastern ghats varies from 100 to 130 km. It has 6 sub-divisions *viz.*, the Southern Andhra Pradesh plains, the Krishna-Godavari delta, the Mahanadi delta, the Kanyakumari coast, the Coromondel coast, and the Sandy coast.

6. Western ghats

It is a narrow strip of land sandwiched between the western ghats and the Arabian sea. This strip begins in Gujarat in the north and extends to Maharashtra, Goa, Karnataka and Kerala. The width of plain is ranging from 50 to 100 km. This coast is covered with small rivers and numerous backwaters. The rivers originate in the western ghats are fast flowing and mostly perennial. The fast flowing nature of the rivers results into the formation of estuaries rather than deltas. The major rivers of western ghat which flow fast and open into the sea are Tapi, Narmada, Mandovi and Zuari rivers. The western coast is divided into three regions *viz.*, Konkan coast, Kanara coast and Malabar coast.

I. **Konkan coast:** It covers the northern region of Maharashtra and Goa.
II. **Kanara coast:** It covers the central region of Karnataka.
III. **Malabar coast:** It is a southern coast line of Kerala. Vegetation in this region is mostly deciduous. The Malbar coast is unique for its moist forests.

7. Islands

India has two offshore islands *viz.*, the Lakshadweep islands and the Andaman and Nicobar islands. Both these island groups are administered by the Government of India as Union territories.

I. **Lakshadweep islands:** It lies approximatly 300 km off the Kerala coast in the Arabian sea. It consists of 12 coral atolls, 3 coral reefs and 5 banks.
II. **Andaman and Nicobar islands:** These islands are located between 6° and 14° north latitude and 92° and 94° east longitude. It is located at a distance of 1,255 km from Kolkata. The Andaman and Nicobar islands consist of 226 islands which lie in the Bay of

Bengal, near the Myanmar coast. The territory of these island consists of two groups *viz.*, the Andaman islands and the Nicobar islands. The Andaman islands consist of 204 islands having the total length of 352 km (220 miles) and the Nicobar islands lie in the south of Andaman, consist of 22 islands with total area of 1,841 km^2 (710 miles).

Some of the significant islands are just off the Indian coast. They include Diu, a former Portuguese enclave; Majuli, Asia's largest freshwater island; Salcette island, India's most popular island on which Mumbai city is located. The Elephanta's caves are in Mumbai harbour and Sriharikota barrier island in Andhra Pradesh. Thus, it may be concluded that India is ecologically widely spread with mountain ranges, plateaus, forests, deserts, ghats, highlands and islands with diverse flora and fauna. These ecological divisions maintain the territory of India.

QUESTIONS

1. Discuss the ecological divisions of India.
2. Describe various mountains in India.
3. Write notes on:
   A. Himalayan ranges
   B. Vindhya ranges
   C. Highlands
   D. Islands
   E. Western ghats
   F. Thar Desert

7

ECOLOGICAL SUCCESSION

Turning from the community organization, another important aspect is the growth and changes in communities through time is ecological succession. When a belt of land in its original vegetation, becomes bare due to fire, flood or glaciation. In such an area is occupied rapidly by a variety of both plant and animal species that subsequently modify one or more environmental factors. This modification of the environment in turn allows additional species to become established. The development of the community by the action of vegetation on the environment leading to the establishement of new species is termed as 'Ecological Succession'. The ecological succession is an universal process of changes taking place in ecological time. These changes may be progressive or retrogressive type. The retrogression in the community occurs when it is disturbed by fire, grazing, scraping or erosion.

The ecological succession, a fundamental concept in ecology, refers to more or less predictable or orderly changes in the composition or structure of an ecological community. The ecological succession may be initiated either by the formation of newly unoccupied habitat *e.g.*, a lava flow in the earth crust or by some form of disturbance like fire, flood etc. of an existing community.

The ecological succession can be separated into two components *viz.*, physiographic and biotic components. The physiographic form of succession was first studied by H.C.Cowles in 1901 with respect to the series of communities that gradually arose as post glacial lake in Chicago was drained away leaving the smaller lake Michigan and the Chicago in its place. The second component in ecological succession is biotic components. It brings significant changes in the community structure through the biological action *e.g.*, numerous changes introduced by the plants and animals in a community. These processes and their effects are collectively termed as development that can be studied in the field and can be demonstrated in the laboratory. These two factors regulate the process of community change. Researches have shown that such changes are relatively continuous and directional, hence may be predicted. This process of change continues till getting stability. The transitional series of communities which develop in a given area are called 'sere' or 'seral stages' while the final stable and mature community is called the 'climax'. Succession and development of a sere are frequently controlled by local conditions rather than prevailing climatic conditions. Local effects are edaphic and the edaphic influences are due to soil and water.

Thus, the ecological succession is the observed process of changes in the species structure of an ecological community, over a period of time. Within any community, some species may become less abundant over a time interval or they may even vanish from the ecosystem altogether. Similarly, due to the time intervals, some other species within the community may become abundant or new species may even invade into the community from the adjacent ecosystems. Such observed changes over time in a particular ecosystem are referred as ecological succession.

HISTORY

The idea of ecological succession goes back to the 19th century. The French Naturalist Adolphe Dureau de la Malle was the first who make use of the word 'succession' about the development after forest was cleared after felling. In 1860, Henery David Thoreau described the succession in an Oak-Pipe forest under 'The succession of forest trees'. H.C. Cowels (1901) developed a more formal concept of succession at Chicago University. Understanding of succession was long dominated by the theories of Frederic Clements, a contemporary of Cowels, who held that successional sequences of communities (seres) were highly predictable and culminated in a climatically determined stable climax. Clements and his followers developed a complex taxonomy of communities and successional pathways. Beginning with the work of Robert Whittaker and John Curtis in 1950-60, models of succession have gradually changed and become more complex. In modern times, less stress has been placed on the idea of single climax vegetation and more study has gone into the role of contigency in the actual development of communities.

OCCURRENCE

Every species has a set of environmental conditions under which it grows and reproduces optimally. Those species that can grow most effectively and produce the most viable offsprings will become the most abundant organism. As long as, the ecosystem is a set of environmental conditions which remain constant and those species optimally adapted to the environmental conditions, that will flourish. The 'engine' of succession is the impact of established species upon their own environmnents. Under the changed condition of the environment, the previously dominant species may fail and another species may become ascendant.

The ecological succession may also occur when the conditions of an environment suddenly and drastically change. A forest fires, wind, storm, and human activities like agriculture greatly alter the conditions of an environment. These massive forces may also destroy species and thus alter the dynamics of the ecological community triggering a scramble for dominance among the species still present.

CAUSES OF SUCCESSION

As the ecological succession involves a series of complex processes, so there may be many causes of succession. Ecologists have suggested three causes of succession *viz.*, initiating, continuing and stabilizing causes.

1. Initiating causes

These causes are climatic and biotic types. The climatic causes includes erosion and deposites, wind, fire etc. which caused by the lightening or volcanic activity. The biotic causes include various activities of the organisms. These causes create the bare areas or destroy the existing population in an area.

2. Continuing causes

Migration, aggregation, competition etc. are the continuing causes of ecological succession.

3. Stabilizing causes

These include factors like climate of an area which results in the stablization of the community.

ECOLOGICAL SUCCESSION

Ecological succession brings changes in the ecosystem development from a young to mature stage. These stages are enumerated here.

1. The changes that take place during any form of succession depend upon a variety of environmental factors *viz.*, moisture, temperature and wind. One possible scenario of primary succession might begin with the appearance of simple plants such as lichens and mosses. These plants are able to spring up in tiny cracks in the rocks in which water and dissolved minerals get collected.
2. When the pioneer plants die, they decompose and begins to form soil in which other more complex plants begin to grow. The second stage of plants consists of grasses, herbs and small shrubs. They may live in only for one year, and spend the greatest part of their energy ensuring that offspring will arise the following year. Species of this kind are known as 'opportunist species'. Grasses are the most important example of such species.
3. Plants that make up the early stages of succession also die, decompose and contribute to the growing layer of soil. This process takes years to together to complete. However, the soil is able to support more complete plants such as large shrubs and small trees including aspen, black spruce, and jack pine. These plants can capture more sunlight that was originally captured by simpler plants.
4. Finally, during succession, taller trees begin to grow. They, in turn, blockout the sunlight needed by smaller trees and replace them. The final stage of ecological succession is known as 'climax community'. A climax community consists of birch, white spruce and balsam fir etc.

TYPES OF ECOLOGICAL SUCCESSION

Ecologists, generally recognize two kinds of succession, *viz.*, primary and secondary succession.

Primary succession: The primary succession takes place in an area which is originally completely devoid of life *e.g.*, an area that has been covered by a flow of lava has no life at all on it over a period of time. However, various kinds of organisms begin to grow in the area. Over a period of time, the variety of life forms change as succession continues.

Secondary succession: It is far more common and occurs in an area where life once existed but has been destroyed. For instance, imagine a forest that has been destroyed by a wild fire. Again, no living organisms may exist in the area. After a long time, however, certain types of plants begin to reappear. As the primary succession, the nature of the plant communities gradually change over time. This is referred as secondary succession.

EXAMPLE OF ECOLOGICAL SUCCESSION

Succession is one of the major theme of our nature's trail. It is possible to observe both the on going process of succession and the consequences of past succession events at almost any point along the trail. The rise and the decline of numerous species within various communities illustrate both the types of motive forces of succession. The impact of an established species to change a site's environmental conditions and the impact of large external forces to suddenly alter the environmental nature of site. Both of these forces necessarily select for new species to become ascendant and possibly dominant within the ecosystem.

Some specific examples of observable succession are as follows:

1. The growth of hardwood trees (including ash, popular and oak) within the red pine planting area. The consequence of this hardwood tree growth is increased shading and subsequent mortality of the sun loving red pines by the shade tolerant hard wood seedlings.

The shaded forest floor conditions generated by the pines prohibit the growth of sun loving pine seedlings and allow the growth of the hardwoods and the decline and senscence of the pine forest.

2. The raspberry thickets growing in the sunlight forest sections beneath the gaps in the canopy generated by wind thrown trees. Raspberry plants require sunlight to grow and thrive. Beneath the dense shade canopy, particularly of the red pine but beneath the dense stands of Oaks, there is no sufficient sunlight for the raspberry's survival. However, in any place in which there has been a treefall the raspberry canes have proliferated into dense thickets. You may observe this successional consequences of macro- ecosystem change within the red pine stand and all along the more open sections of the trail. Within these raspberry thickets, by the way, are dense growths of hardwood seedlings. The raspberry plants are generating a protected 'nursery' for these seedlings and are preventing major browsers of tree seedlings (the white tailed deers) from eating and destroying the young trees. By providing these trees, a shaded heaven in which the raspberry plants grow are setting up the future tree canopy which will extensively shade the future forest floor and consequently prevent the future growth of more raspberry plants.
3. In the success of 'garden plot', the initial plant community that was established within the boundaries of this plot was made up of those species that could tolerate the periodic trimming that controlled this grass ecosystem. Soon, other plant species become established as a consequence of removal of the stress of mowing. Over time, the increased shading of the soil surface and the increased moisture retention of the undistributed soil-litter interface allowed an even greater diversity

of plants to grow and thrive in the garden succession. Eventually, taller wood plants become established which shaded out the sun loving weed community. In future, we expect tree seedlings to grow up within the garden succession and slowly establish a new section of the forest.

EFFECTS OF ECOLOGICAL SUCCESSION ON MANKIND

Ecological succession is a force of nature. In ecosystem, because of the internal species dynamics and restructuring, many changes take place in the community structure. To appreciate how ecological succession affects the human and also to appreciate the incredible time and monetary cost of ecological succession, one has to visualize a freshly tilled garden plot.

Cleaning of land for garden and preparing the soil for planting represent a major external events that radically restructures and disrupts a previously stabilized ecosystem. The disturbed ecosystem will immediately begin a process of ecological succession. Plant species adapted to the sunny conditions and the broken soil will rapidly invade the site and will become quickly and densly established. These invading plants are weeds. The weeds have very important role and functions but weeds are also competitors with other garden plants for nutrients, water and physical space. A gardener's only course of action is to spend a great deal of time and energy during deweeding the garden. This energy input is directly proportional to the energy inherent to the force of ecological succession.

CONTROL OF ECOLOGICAL SUCCESSION

In ecological succession, there is a concept called climax community. The climax community represents a stable end product of the successional sequence. In the climate and

landscape region of the nature trail, climax community is 'Oak forest', a subdivision of the Deciduous forest biome. An established Oak forest will maintain itself for a long duration. Its structure and composition will not change for a observable time. To this degree, ecological succession has stopped over the long period of time (geological time), the climate conditions and other fundamental aspects of an ecosystem change. These geological time-scale changes are not observable in ecological time but their fundamental existence and historical reality cannot be disputed. No ecosystem then has existed or will exist under changed conditions over a geological time scale.

SIGNIFICANCE OF ECOLOGICAL SUCCESSION

As succession goes forward, the nature of plant communities changes significantly. Instead of sending out many seeds each year, as in a pioneer community, trees in more mature communities devote their energies in sending out roots, branches, leaves and other structures. As they grow larger and create more shade, they actually prevent the germination (first life stage) and growth of their own seeds and seedlings. Thus, ecological succession plays a significant role in the development of communities.

Periodicity

It is one of the major and basic feature of the animal community. Most of the animals do several activities in search of food, shelter and mates. Their activities fall into two categories: (i) periodic, and (ii) non-periodic activities. It was observed that most of the large activities of the communities are periodic in nature and correlated with the day-night length, day light intensity, air temperature and distribution of precipitation. Infact, the correlation of the community activity in large-scale with the physical environment is essential for survival.

Periodic activities

These activities are of three types at the level of major community *viz.*, seasonal periodicity, lunar periodicity, and, diel periodicity.

Seasonal periodicity: It involves the growing of plants seasonally. It serves as mating period for some animals. The seasonal periodicity covers all the aspect of dormancy including hibernation and aestivation, the correlations in photoperiodicity or relationship between the flowering, fruiting of many plants with relative length of the day and night throught the year, and the problem of migration. If we study the periodicity in the sense of seasonal events, it is known as phenology and the sequence of phenological changes are followed through the annual cycle and related to the environmental factors is referred as seasonal succession. Generally, the year is divided into a series of periods that are correlated with the seasonal phenomena such as peak of abundance of a certain population of a particular community.

Lunar periodicity: Within the seasonal frame, certain animals exhibits reproductive phenomena which are correlated with the tidal or lunar events *e.g.*, certain marine annelids that swarm and spawn at certain times in certain months. All such phenomena are known as lunar periodicity.

Diel periodicity: The changes in the community activity that are correlated with the regular march of day and night is referred as diel periodicity. These are divisible into diurnal and nocturnal activities, associated with the day or night activities. The most important diel activity is the diurnal manufacture of carbohydrates by the photosynthetic plants. The nocturnal process is the distribution of much of this carbohydrates material into other part of the terrestrial plants. Another diel phenomenon is the vertical migration of many minute animals that inhabit the surface stratum of the sea *e.g.*,

protozoan, copepods and cladocerans. These organisms move to the surface during the night and move downward during the day due to the direct or indirect response to the light intensity. It was studied and found that almost all communities are divisible into two periodic fauna; the diurnal and the nocturnal.

Non-periodic activities

The non-periodic activities do not exhibit the rhythmic correlation with the 24 hrs cycle of the day-night. These non-periodic activities are also known as aperiodic activities. In non-periodic species and populations, some individuals are active and some are inactive at any given time. Such aperiodic patterns are of two kinds: (i) there are those species which inhabit relatively stable environment that are removed from direct periodic diel influences *e.g.*, Cave crayfish of Mammoth cave; and (ii) as many kinds of ants, termites and social organization of man, as their whole activites become correlated with relatively constant environment and is a complex social medium or habitat that is removed from direct control of diel factors.

Indicators

Indicators enables the communities to measure progress towards or away from becoming a green community. It is important to connect the peoples with ecosystems that support them. As a society, we can either live with nature or make nature live with us. For generations, we have consumed more than our share of the natural resources. In the process, we have cut down much of our virgin forests and filled or drained significant acreage of wetlands. It is a time for communities to utilize the knowledge, technology and resources available to live sustainably. Indicators are needed to show trends and to measure progress towards goals. The communities need some order to the chaotic possibilities of indicators. Several frameworks are being

used by the communities to help for developing sustainable indicators.

The environmental indicators look at the effects of human activities on the environment as well as the implications of these actions on human health, quality of life and the integrity of ecosystems. Environmental indicators are usually scientifically based information that describe environmental conditions and trends. Reliable information about the current state of the environment and the factors that stress, are essential for making appropriate future commitments of times, energy, and resources to meet environmental challenges. For example, vehicle miles travelled (VMT) versus population was an indicator examined by the Chesapeake Bay Programme (CBP) for land, growth, stewardship and sustainable use of indicators workgroups to encourage efficient development patterns. The status of their findings was that the vehicle miles travelled in the Chesapeake Bay watershed increased upto 80% between 1971 and 1994. Population during the time increased only by 26%. VMT are projected to increase an additional 33% and population expected to increase by 12% between 1995 and 2010; if current trend continues. These thoughts are helpful to us for becoming our community to be low in population in the near and distant future.

WORDS TO KNOW

1. **Climax community:** A relatively stable ecosystem characterized by large old trees that mark the last stage of ecological succession.
2. **Ecosystem:** An ecological community, including plants, animals and micro-organisms considered together with their environments.
3. **Opportunist species:** Plant species with short life spans that devote most of their energy in producing seeds.

4. **Pioneer plants or communities:** Plants or communities that are the first to be established in an area previously empty of life.
5. **Primary succession:** Succession that takes place on an area that was originally completely devoid of life.
6. **Secondary succession:** Succession that occurs in an area where life once existed but has then been destroyed.

QUESTIONS

1. Write an essay on ecological succession.
2. Explain ecological succession with its example, causes, stages and types.
3. How the ecological succession affects to the mankind and how to control it?
4. What is the significance of ecological succession?
5. Write short notes on:
   A. Primary succession
   B. Secondary succcession
   C. Climax community
   D. Periodicity
   E. Indicators

8

FRESHWATER HABITATS

In nature, a number of organisms were found. They used to live single or in groups. Their place of living is referred as habitat. The term 'habitat' can be used more easily in environmental science or in ecology. A 'habitat' is an ecological or environmental area that is inhabited by a particular species. It is the natural environment in which an organism lives or the physical environment that surrounds a species population. According to Clements and Shelford (1939), the term 'habitat' was originally defined as the physical conditions that surround species, or species populations, or assemblage of species or community. Thus, it is not just a species population that has a habitat, but an assemblage of many species living together in the same place that essentially share a habitat. In environmental science, any habitat is shared by many organisms. A biome is a set of flora and fauna which lives in a habitat and occupies certain geographical area. Thus, the habitat provides shelter to the organisms. Destruction of habitats is a major factor for reducing the population of a species, eventually leading to its being endangered or even to its extinction. The large-scale land cleaning usually results in the removal of native vegetation and habitat destruction. Forest fires, storms, floods, cyclones, pest and weed invasion etc. can also destroy the habitats. The national parks, nature reserves and other protected areas help for

preserving the habitats. Thus, habitat ecology deals with the study of habitat of a particular species or a biotic community. A 'micro-habitat' is a physical location that is home for a very small creatures *e.g.*, woodlice. Micro-environment is the immediate surroundings and other physical factors of an individual plant or animal within its habitat.

Habitat approach to nature is very important, as its aim is to study the organism and non-living factors operating there. There are two major types of habitats in the biosphere *viz.*, aquatic habitats and terrestrial habitats. The aquatic habitats may be of three types: freshwater, marine water and estuarine habitats. Terrestrial habitat are realms and biomes including Tundra biomes, forest biomes, grassland biomes etc.

FRESHWATER HABITATS

As per the global distribution of water, earth is surrounded by 71% water spread area and in 29% there is land. On this land, there are many sources of water *viz.*, rivers, streams, lakes, reservoirs etc. These water bodies are known as freshwater bodies as their salinity is less than 0.5 ppt and the habitat is called as freshwater habitat. The study of freshwater habitats is also known as freshwater ecology. It is divided into two groups: (i) Lentic habitats or standing water habitats, and (ii) Lotic habitats or running water habitats.

LENTIC HABITATS

The lentic habitats are the standing water habitats. Examples of freshwater habitats are pond, lakes, marshes, swamps, bogs, reservoirs etc. In these habitats, water is to be preserved naturally or artificially. To understand the lentic habitats, take an example of lake or pond.

Lakes and ponds: The lakes are the lentic or standing water bodies whose size varies from few hectares to thousand of square kilometers. Their depth also varies from few meters to several meters. Generally, lake water is freshwater whose salinity is less than 0.5 ppt. In lake a number of liters water is present and this water divides the lake into different zones (Fig. 8.1). These are: Littoral zone, Sublittoral zone, Limnetic zone, Profundal zone, and Abyssal zone.

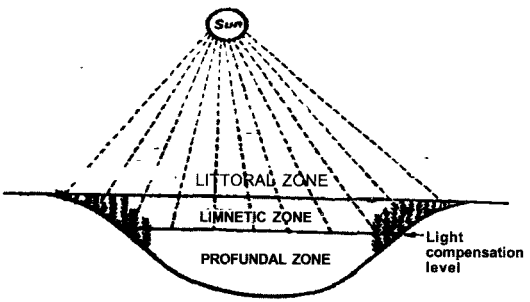


Fig. 8.1: Different zones of a lake

i. **Littoral zone:** The littoral zone is a shallow water zone and it contains warm water and rooted vegetation. The littoral zone is followed by sub-littoral zone.

ii. **Sublittoral zone:** The sub-littoral zone contains cold water and poor oxygen concentration. It is also refers as 'hypolimnion'.

iii. **Limnetic zone:** It is open water zone and away from the shore. This zone is upto the depth of effective light penetration where the rate of photosynthesis is equal to the rate of respiration.

iv. **Profundal zone:** This is deep water zone and it is beyond the depth of effective light penetration.

v. **Abyssal zone:** The abyssal zone is found only in very deep lakes. This zone starts at 2,000 m from the surface.

Thus, on the basis of light penetration, lakes and ponds are classified. The ponds are the small water-bodies and in them all these zones are not found; only 2-3 zones are found.

Communities of lentic habitats : The major lentic water communities are algae, bacteria, fungi, plankton, nektons, neustons and benthos. Their species composition varies from zone to zone.

i. **Neustons:** The neustons are the unattached organisms and found at the surface of water. They may include floating plants.
ii. **Plankton:** Plankton also floats on the surface or sub surface of water. They may be phytoplankton or zooplankton.
iii. **Nektons:** The nektons are swimming animals and they are fast runners. Mostly nektons includes insects, size may be 2 mm to large animals *i.e.*, Blue whale.
iv. **Benthos:** Benthos include bottom organisms. The bethic organisms living above the sediment-water interface are termed as 'benthic epifauna' and those living in sediment itself are termed as 'infauna'.

The water surface of a lake or pond contains certain free floating, hydrophytes such as *Wolffia, Spirodella, Azolla, Salvinia, Pistia* and *Eichhornia.* These plants remains in contact with water and air, but not with soil.

According to the zonation, the various organisms are distributed in different zones, *i.e.*, in littoral, limnetic and profundal zones.

In littoral zone, producers are: (a) rooted plants or benthic plants, mainly seed plants and (b) floating green plants, the phytoplankton, mainly algae like diatoms, green algae, filamentous algae like *Spirogyra, Zygnema, Oedogonium, Cladophora, Chara* etc. In this zone,

counsumers like pond snails, nymphs, rotifers, flatworms, hydra, some insect larvae etc. are found.

In limnetic zone, the producers are phytoplanktonic algae, which include diatoms, green algae and blue green algae. The consumers of the limnetic zone are zooplankton *viz.*, copepods, cladocerans, and rotifers are chiefly present. Swimming (nectons) animals in this zone are exclusively fishes.

In profundal zone, the organisms mainly depend for their food on the littoral and limnetic zone. Since, there is no penetration of effective light to this zone. Major life forms of this zone are bacteria and fungi, which are quite abundant in the water mud interphase; bloodworms containing chironomid larvae, annelids and small clams. All these organisms are adapted of the with-stand periods of low oxygen concentrations. The producers and consumers present in the lentic habitat are shown in the Fig. 8.2.

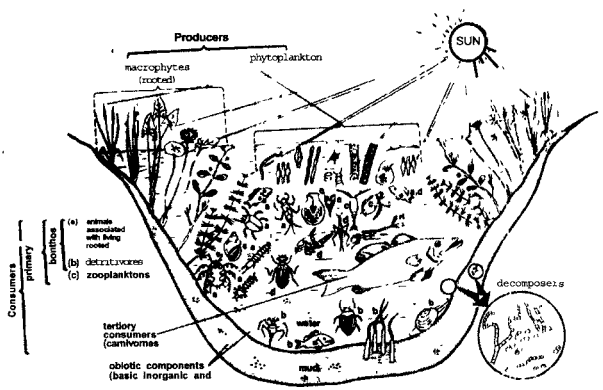


Fig. 8.2: Communities of lentic habitats

Difference between the lakes and ponds: The lakes, in addition to being larger in size than the ponds, also show some ecological differences. These are as follows:

(i) In lakes, the limnetic and profundal zones are relatively large, than the littoral zone, whereas, in ponds, it is reverse.
(ii) The lakes show stratification in certain seasons and in ponds, there is limited stratification of temperature and oxygen.

LOTIC HABITATS

The lotic habitats are the running water habitats. They include rivers, streams, springs etc. The remarkable lotic habitats in India are rivers *viz.*, Ganga, Yamuna, Sutlaj, Brahmaputra, Narmada, Krishna, Cauvery etc. In these lotic habitats, the flow of water is continuous and down to the surface. Depending upon the velocity and rate of flow, lotic habitats are divided into two systems, *viz.*, rapidly flowing and slowly flowing lotic habitats.

Rapidly flowing lotic habitats: In rapidly flowing lotic habitats, the flow of water is rapid and turbulent example is a stream. Everything which has no attachment or weight is swept away by the current. This includes organisms and sediment particles alike. The substrate tends to be rocky or gravel type. In this habitat, sheer force and rate of water movement is quite different. Aquatic plants, provides micro-habitats for some torrential animals. The rarely occurring phytoplankton of this habitat are diatoms, blue green algae and green algae (*e.g.*, *Cladophora, Ulthrix*) and water moss (*Fontinalis*). In physical and chemical sense, the rapidly flowing lotic habitats resemble with the cold and deep lakes. In this, water temperature tends to be quite low, productivity is also quite low but diversity is high. Here, the main control of the productivity is due to the water-current, which seriously limits the amount and type of autotrophs production that can takes place. In rapidly flowing lotic habitats, the different biotic communities found are listed as follows:

1. Plant inhabiting torrential forms
2. Rock inhabiting forms, and
3. Inhabitants occurring beneath the rocks.

1. **Plant inhabiting torrential forms:** These are mosses and flowering plants such as *Duroea wallichii, Eriocaulon miserum* and *Hydrolyum lichenoides* are also present. Animals are funnel mouth tadpoles. These possess device for fixation and have hydrostatic organs also.
2. **Rock inhabiting forms:** These are animals like freshwater limpets, water penny, the larvae of the riffle beetle, freshwater sponges, caddisflies etc.
3. **Inhabitants occurring beneath the rocks:** A number of species such as flatworms, annelids, insect larvae, clams and some species of snails live beneath the rocks. The current is weaker here, and animals are less likely to be carried away. They lack any special adaptation.

It was observed that if the current is sufficiently slow, certain swimming organisms such as fish will be present. These fishes may be stenothermal cold water fish, such as trout. The fishes of fast water system have small size and streamlined body *e.g.*, Trout and Mahasheer fishes are capable of moving against the current or waterfall by muscular efforts.

Slowly flowing lotic habitats: The slowly flowing lotic habitats are somewhat different from that of rapidly flowing lotic habitats. The nature of these habitats is slow and laminar, their errosive power is reduced and small sedimentary particles (silt) and decaying organic debris are deposited at the bottom. These habitats have higher degree of temperature and the plankton concentration is higher in such habitats. Benthos, molluscs, isopodes, mayfly, tapeworms, insect larvae, clams, nematodes, snails and rotifers make the fauna of slow flowing lotic habitats.

In such habitats, swimming organisms are abundant *viz.*, fishes, crustaceans and insects. Zooplankton are also present in slow flowing water. These include a rich assemblage of protozoan and smaller crustaceans such as cladoceran (water fleas) and copepods. Reptiles are also present in this habitat. These are water snakes, crocodiles and turtles. Amphibians such as frogs are also present in such habitat.

When we see plant life in slow flowing lotic habitat, it is also in abundant. The rooted vegetation, pond weeds and grasses, algae like diatoms and flagellates are found in the open water system. Further, bacteria and fungi are also present in such habitats. They decompose the organic debris. In the bottom mud of such habitats there is more organic material than mineral fragments.

It is observed that in slow flowing water (lotic habitats) contains low concentration of dissolved oxygen and many fishes are adapted to this environment. These include carps and catfishes. The fishes requiring higher concentration of oxygen as trouts are found in the fast flowing lotic habitat.

DIFFERENCE BETWEEN LENTIC AND LOTIC HABITATS

In ecological sense, there is a difference between lentic and lotic habitats. The chief ecological difference are as follows:

1. The lentic habitats are the standing water bodies, whereas, the lotic habitats are running water-bodies.
2. Concentration of dissolved oxygen is less in lentic habitats and more in lotic habitats.
3. Examples of lentic habitats are ponds, lakes, reservoirs etc. while, lotic habitats includes rivers, streams, springs etc.

EFFECTS ON FRESHWATER HABITATS

The freshwater habitats are adversely affected by a number of human pressures including:

1. Excessive ground water and surface water abstraction.
2. Pollution especially eutrophication and acidification of aquatic habitats.
3. Effects of inappropriate land use or poor management *e.g.*, aforestration, large drainage and overgrazing.
4. Introduction of invasive plant and animal species.
5. Urban, industrial and agricultural development within catchments.
6. Inappropriate development of recreation and navigation.
7. Inter-basin water transfer schemes and the construction of dams and reservoirs.

For the effective conservation of freshwater resources requires integrated catchment management, involving a mixture of environmental incentives, statutory controls, educational initiatives and guidelines. The Water Framework Directive (WFD) is a major piece of new legislation whose principal objective is to ensure that all surface waters attain good ecological status by 2015.

QUESTIONS

1. Discuss the freshwater habitats in India.
2. Explain the terms lentic and lotic habitats.
3. What is the difference between lentic and lotic habitats.
4. Write short notes on:
   A. Lentic habitats
   B. Lotic habitats
   C. Effects on freshwater habitats
   D. Habitat ecology

9

MARINEWATER HABITATS

The marine habitats are the largest aquatic habitats on the earth. These habitats include seas and oceans and cover around 70% of the earth surface and contain many biotic communities. Here, the life extends to all the depths of oceans, although it is much dense around the margins of continents and islands. However, all the oceans around the globe are inter-connected. Temperature, salinity and depths are the chief barriers for the free movements of marine organisms. The sea is in continuous circulation because air temperature differences between the equator and poles set up strong winds which together with rotation of the earth, create definite currents. The sea is dominated by waves and tides. The sea water is saline and salinity is upto 30-35 ppt. Higher salinity is mainly due to the chloride ions present in the water. Salinity and temperature are the two important limiting factors of the sea.

Study of marine habitats is also known as marine ecology, marine biology, oceanography etc. and the study of these habitat is of very interesting due to its large space and communities. Marine ecology is a branch of ecology which deals with the interdependence of all living organisms in the ocean, in shallow coastal waters, and on the seashore. The marine environment includes abiotic factors and biotic communities. Abiotic factors are light, water, soil, temperature, pH, salinity, dissolved oxygen

and other gases, substratum, nutrient supply, pressure, tides, currents, waves etc. The biotic factors are the marine communities and interact among the living organisms. Many marine species are economically important to the human beings including food fishes. It is understood that the well being of marine organisms and other organisms are linked in very fundamental ways. Human understanding is growing regarding the relationship between life in the sea and important cycles *viz.*, carbon cycle, water cycle and with air. Large areas beneath the ocean's surface still remains effectively unexposed. Marine habitat or ecology studies of the habitats *viz.*, coral reefs, tide affected areas, muddy, sandy and rocky bottom and the open ocean zone where solid objects are rare and the surface of water is the only visible boundary.

FACTORS AFFECTING THE MARINE ENVIRONMENT

There are many factors which affect the marine environment. These are light, temperature, pressure, salinity, tides and currents.

1. **Light:** Light is an important factor in regulating the marine environment. It contributes significantly to the marine organic production. The autotrophic organisms synthesize the solar energy through the process of photosynthesis which depends upon the intensity of light and turbidity of water. Light determines the diurnal migration of the marine organisms and also regulates the colouration in marine animals. Deep sea animals are colourless due to the absense of light. It is also related with visual sense in the organisms.
2. **Temperature:** Temperature of marine environment is quite less than on land. It ranges from 2 to -27°C. There is a variation in the seasonal and daily

temperature. The surface of coastal waters is very low but never below 2 to 3°C. At any given place, the temperature of deep water is almost constantly cold. Sea water does not have a maximum density at 4°C rather it becomes continuously denser as it gets colder.

3. **Pressure:** The pressure of the marine environment is very high. It varies from 1 to 100 atm at the greatest depth. Certain organisms are restricted to the surface waters when their pressure is low, whereas, the other organisms are adapted to life at great depths. Some marine organisms *viz.*, Sperm-whale and certain seals can dive to great depths and return to the surface without any difficulty.
4. **Salinity:** Salinity is a important factor of the marine environment. It is ranging from 35 to 300 ppt and also varies from place to place. Salinity is mainly due to the presence of salts in the marine water. The main salts present in sea water are chlorides, sulphates, bicarbonates, carbonates, bromides etc. The concentration of sodium chloride is more. The process of osmo-regulation occurs in marine animals. These animals are adapted to the higher salinity.
5. **Currents:** Sea water is never static and waves, currents and tides are the regular features of sea water. These phenomena are controlled by winds, cosmic rays and water densities. Higher currents occur at surface water and at great depth of the sea water. These currents mix into the superficial and deep waters together. Similarly, horizontal and vertical movements of the current are also important in various ways. In marine ecosystem, the oceanic currents control the productivity of the marine communities through vertical mixing of water masses. There are certain regions in the world, specially West coast of continents and sub-polar regions where deep currents rise to the surface and

it is referred as 'zones of upwelling' and this water zone is very cold. These sites have intense productivity due to the higher concentration of nutrients. Nutrients are then cycled backed to the rest of the ocean via surface currents.

6. **Tides:** Tides influence the seashore fauna as low tide expose to the shore and high tide results into flood position. Tides caused mainly due to the pulling of moon and sun to the earth. They represent a rhythmic rise and fall of water and often waves of long wavelengths characterize the process.

ZONATION OF OCEANS

There are two major zones of the oceans *viz.*, pelagic zone and benthic zones.

1. **Pelagic zone:** The pelagic zone includes the productive coastal water. It is divided into neritic zone and oceanic zone. The neritic zone is a shallow water zone and oceanic zone is a zone of deep waters of the open ocean. Another division in the pelagic zone is related to the light penetration. The zones are the photic and aphotic zones. The biota of pelagic zone is pelagic biota.
2. **Benthic zone:** The benthic zone is a bottom zone of ocean. It extends from the seashore to the deepest part of the sea. In this zone, benthic organisms are found. They are also known as 'benthos'.

STRATIFICATION OF MARINE ENVIRONMENT

The upper layer of oceanic water exhibits the stratification of temperature and salinity. Depths below 300 m are usually thermally stable. In high and low latitudes, temperature remain fairly constant throughout the year. In middle latitudes temperature vary with the season, and

is associated with the climatic change. During summer, the surface waters becomes warmer and lighter forming a temporary seasonal thermocline. In sub-tropical regions, the surface water are constantly heated, developing a marked permanent thermocline. At 500 to 1,500 m a permanent but relatively slight thermocline exists.

MARINE COMMUNITIES

Marine biota is abundant and contains well marked diversity. A major group of algae and animals found all over the oceans. The only striking omissions are the vascular plants and insects, which are abundant in the estuaries but have few or no marine representatives. Marine communities are classified into producers and consumers. Producers are phytoplanktonic diatoms, dinoflagellates, green algae, brown algae and red algae etc., whereas, consumers are zooplankton, benthos, nektons, neustons and bacteria. These biotic communities are studied separately according to their occurrence and zonation of the ocean into two parts as follows:

1. Biotic communities of oceanic region,
2. Biotic communities of continental shelf.

1. Biotic communities of oceanic region

The biotic communities of the oceanic or pelagic region are less in numbers but they are characteristic species. Many of these species are transparent or bluish due to the sediment free water. Further, the animals of the pelagic zone of ocean encounter stable and uniform environmental conditions due to the continuity of sea water, causes the individuals of the open ocean to stay away temporarily or permanently from any solid object and they are provided with different locomotory organs. However, plankton lack locomotory organs and float on the surface of ocean. The

biotic communities of the pelagic and oceanic zone are as follows:

I. **Biotic communities of pelagic zone:** The pelagic plankton also referred as epiplankton and they are diverse. The biotic communities of pelagic zone are as follows:

   a. **Phytoplankton:** These include diatoms and dinoflagellates which produce organic carbon in the sea water as well as other form of golden brown algae and flagellated green algae are present. Some sea weeds like large brown algae are also found.

   b. **Zooplankton:** Zooplankton of pelagic zone include representatives of every major phyla and most minor phyla, either as permanent members of the plankton community (holoplanktonic forms) or as transients forms during their larval stages (meroplanktonic forms). Most common zooplankton are foraminifera and radiolaria, arrow worm (*Sagitta*), certain annelids, swimming snails, jelly fishes, crustaceans like shrimps, copepods and cladocerans.

   c. **Nektons:** Nektons are the large animals of the pelagic region. These include cephalopodes *viz.*, squids and nautili among invertebrates as well as many marine vertebrates such as bony fishes, sharks, sea turtles and whales. Besides, sea birds also feeds on the large carnivores. Air breathing nektons *viz.*, turtles, whales are also found in the photic zone but fishes extend from sea surface to the bottom. Certain fishes such as tuna, shark, shardine, mackerel, herring, bonite etc. lives near the surface. There is a scanty food in the deep sea water. So these fishes remain live without food, when they get it, they consume as much as they can do, in an opportunity.

II. **Biotic communities of oceanic zone:** In the benthic zone, there is absence of light. So there is no possibility of vegetation or other photosynthetic organisms. However, the deep ocean benthos are surprisingly diverse. Food is little plentiful in the bottom of the ocean. The bottom of the sea is a soft ooze, made up of the organic remains and shells of foraminifera, radiolaria, and other animal and plants. The benthic communities of pelagic zone include sea cucumber, brittle stars, sea lilies, sea urchins, certain benthic fishes, crustaceans, as well as sea anemones, clams etc. The great diversity of the benthic zone is related with the great consistency in the physical environment of the deep sea.

2. Biotic communities of the continental shelf

The biotic communities of the continental shelf are rich and diverse than the oceanic region. Phytoplankton like diatoms and dinoflagellates are still productive but in the shallow region green, brown, and red algae are present in the bottom, which may be of great importance. These sea weeds harvested from rocky shores as a human food or for commercial purpose. The zooplankton of the continental shelf are generally same as that of the pelagic zone but some pure pelagic species are replaced by neritic species and the overall diversity is very high. The temporary zooplankton are more abundant in the continental shelf region than in the open ocean.

The nektons of the neritic sea are diverse and well known. These include large squids, whales, seals, sea otters, and sea snakes. Fishes like sharks, sardine etc. Cods and their relatives such as haddock and pollack; salmon and sea trout, flounder and other flatfishes such as sole, halihut; mackerels including tuna and bonito are also found in this community.

Ecologists have recognized three major types of intertidal zone or seashores *viz.*, rocky, sandy, and muddy. The rocky and sandy shore communities are explained as follows:

I. **Biotic communities of rocky shore:** The rocky shore is a solid substratum for the attachment of many sessile animals which are abundant. These sessile animals are sedentary and inhabit rocky shores are limpets *viz.*, *Patella, Haliotis, Fissurella*, oysters, barnacles, tunicates and bryozoans. Sponges are attached to the rocks. In this rocky shore, beside sponges, annelids and molluscs are also present and they are adapted for the filter feeding. Furthermore, all these animals of rocky shore occur in successive zones.

II. **Biotic communities of sandy shore:** The sandy shore are characterized by the gentle wave action. Due to the prolonged time taken for drying, these beaches are suitable for animal life. Decaying of the sea weed and dead remains of the animals result into addition of organic matter to the sand. The principal groups of biotic communities of sandy shore are nematodes, turbellarians, annelids, gastrotrichans and acrainans. Certain animal groups such as protozoa and oligochaetes occur sporadically at different levels. Harpactoids and copepods remain restricted to the mid-tide level. Tardigrades occupy the region between the mid-tide and high-tide. Thus, sandy beaches also possess characteristic zones or zonation of animals.

QUESTIONS

1. What do you understand from the marine habitat?
2. Explain different physico-chemical factors influencing the marine environment.

3. Discuss the marine communities.
4. Write short notes on:
   A. Zonation of ocean
   B. Stratification of marine environment
   C. Marine habitat

10

ESTUARINE HABITATS

The word 'estuary' is derived from the Latin word *'aestus'* which means 'tide' and *'logos'* means 'study'. Thus, an estuary is a tidal part of the river which is strongly affected by the tidal action. Estuaries can be defined as the transitional zone between sea and river and the habitat refers to 'estuarine habitat'. As we know, water of all the streams and rivers drain into the sea; the place where this freshwater joins to the salt water is called 'estuary'. The estuaries are the unique sites of ecological properties, which possess a characteristics biological make up. They are semi-coastal water-bodies. Examples of estuaries are river mouths, coastal bays, tidal marshes and water-bodies behind the barrier beaches. Not all the rivers open into the estuaries but some simply discharge their water into the ocean. When the river reaches to the encroaching sea, the streams carry sediments which are dropped into the quite water. These accumulate and form 'deltas'. When silt and mud accumulate and become high enough to be exposed at low tide then 'tidal flats' develop. These tidal flats divide and braid the original channel of estuary. If more material is deposited than the carried away, island, lagoons or barrier beaches may be formed. Study of estuarine habitat is an interesting phenomenon as it is neither freshwater nor marine water. The estuary, its types, factors influencing estuaries and biotic communites of estuaries are discussed here.

TYPES OF ESTUARIES

Estuaries were studied and classified by various ecologists, hydrologists. In 1969, Odum and his team classified the estuaries on the basis of ecosystem energetics into 5 types: Physically stressed system of wide latitudinal range, Natural arctic ecosystem with ice stress, Natural temperate ecosystem with seasonal programming, Natural tropical coastal ecosystems of high diversity, Emerging new systems associated with man.

On the basis of water circulation and stratification, estuaries are of 4 types: Highly stratifed or salt wedge estuaries, Partially mixed stratified estuaries, Completely mixed or vertically homogenous estuaries, Hypersaline estuaries.

Based on the geomorphology of estuaries, they are divided into 5 different types: Drowned river valleys, Ford type estuaries, Bar-built estuaries,Tectonic estuaries, and River delta estuaries.

Factors influencing the estuaries

There are many factors which influence the estuaries. The important ones are current, salinity, tide, temperature, productivity and nutrient contents. These are explained as follows:

1. **Currents:** Estuarine currents are resulting by the interactions of one direction stream flow, which varies with the season and rainfall and with the oscillating ocean tides and the wind flow.
2. **Salinity:** The salinity of estuaries varies vertically and horizontally and fluctuates amazingly from 0.5 to 35 ppt. The estuarine water is also known as brackish water.
3. **Tides:** These are mainly due to action between earth and moon. During high tide, sea water mixes with

freshwater and at the low-tide, it again goes back into the sea. There is a tidal time table, it shows the time of tides. The tides act as a plunger to flush the estuary and mix the freshwater and salt water. This results into the fluctuation of water level in estuaries and coastal belt.

4. **Temperature:** The temperature of estuaries fluctuates considerably diurnally and seasonally. Water is heated due to the solar radiations. The upper layer of estuarine water may be warmer in summer and cooler in winter season, whereas, bottom layer remains cool as light is not able to penetrate upto the bottom.
5. **Productivity:** All the estuaries have high productivity. High productivity of the estuaries is mainly due to the nutrients and coral reefs.
6. **Dissolved oxygen:** The concentration of the dissolved oxygen in estuaries is fairly high. It is mainly due to the tidal action.
7. **Nutrients:** Tides mix the nutrients and energy material into the estuaries. The mechanism of the nutrient concentration is very simple - particulate nutrient material enters into the estuaries at its upper end and carried seaward by the falling tide and is brought back through the estuary by rising tide and so on for several cycles. Thus, the estuaries act as a nutrient trap, with high nutrient contents. Similarly, the concentration of energy rich organic materials remains high in estuaries.

Biotic communities of estuaries

An estuary being a transitional zone between the freshwater and seas and it is an ecotone, therefore, typical estuarine forms are unique in their habitat. The estuarine community is a mixture of 3 components *viz.*, the

freshwater, marine water and brackishwater. However, the diversity is maximum in brackish water. Total diversity of the estuarine community is lower than normal environments. The number of interactions between species is low and some estuarine populations may fluctuate greatly in size. The plants of estuaries are of four types: phytoplankton, marginal and marsh vegetation, mud-flat algae and epiphytic plants growing on the marginal marsh vegetation. As the turbid water found in estuaries, phytoplankton are normally uncommon. The phytoplanktonic forms found in estuaries are several species of diatoms *viz.*, *Syndra, Navicula, Cyclotella, Triceratium* etc.; several species of green algae such as *Spriogyra, Closterium, Zygnema, Volvox, Chlorella* etc. and blue green algae like *Microcystis, Oscillatoria, Anabena* etc. as well as sub-merged filamentous algae like *Chara, Cladophora* and Enteromorpha. A very few animals feed on these plants directly but a very large amount of detritus is consumed.

The estuarine animal communities include zooplankton and other animals, *e.g.*, protozoan like *Euglena, Ceratium, Noctiluca, Difflugia, Vorticella* etc., rotifer species such as *Keratella, Brachionus* etc.; Copepods such as *Cyclops*, *Diaptomus*; Cladocerans are *Moina*, *Daphnia* etc. Besides these, isopods are also reported. All these forms remain confined to the water and lead a pelagic existence. The well known estuarine animals are detritus feeders *viz.*, Oysters, Clams, Lobsters, and Crabs. Several insect larvae, annelids, molluscs enter into the estuaries from freshwater habitats while the marine phytoplankton, crustaceans, annelids, anemones and bryozoans enters into the estuaries from the marine habitats. Thus, the estuarine communities are unique and diverse due to their origin in both the freshwater and marine habitat.

QUESTIONS

1. What do you understand from estuarine habitat?
2. Explain various biotic communities found in estuaries.
3. Discuss the estuarine habitat.
4. Write short notes on:
   A. Estuaries
   B. Types of estuaries
   C. Factors influencing the estuaries
   D. Biotic communities of estuaries

11

TERRESTRIAL HABITATS

As 71% part of the earth is submerged within water and remaining 29% part is covered with land. On this land so many organisms including plants, animals and micro-organisms live. These organisms interact with each other and exist in this habitat. The habitat in which organisms live on the land, such habitat is known as 'Terrestrial habitat' and the study is called as terrestrial ecology. A terrestrial habitat is a three phase system which includes atmosphere, soil and biotic communities. Atmosphere is a source of oxygen for animals and carbon dioxide for plants. The air serves as a medium for plants, animals and micro-organisms. In terrestrial habitat, the soil serves two important functions: (i) it provides support to the living organisms, and (ii) it is a source of nutrients for all the living organisms. The role of soil is as a source of nutrients, is unique to the terrestrial environments. It is the site of the entire detritus food chain and thus, it is a centre of biogeochemical cycle. The productivity of a soil depends upon its nutrient contents. Thus, in terrestrial habitats the atmosphere, soil, and biotic communities form the base of life on the land. The different kinds of terrestrial habitats, biotic communities and the factors influencing terrestrial habitats are discussed here.

FACTORS AFFECTING THE TERRESTRIAL HABITATS

Following important factors affect the terrestrial habitat:

1. **Temperature:** In terrestrial habitat, temperature varies from place to place and seasonally. During summer, it is very high (around 45°C to 50°C), whereas, during winter, it comes down to 15°C or even 0°C at some places. In monsoon season, it remains in the medium range (25°C to 35°C). Thus, there is a fluctuation of temperature, and it is necessary for the metabolic activities of organisms.
2. **Light:** The intensity of sunlight also varies greatly. Many biological factors, degree of latitude climatic factors and quantity of sunlight reaching on the earth are responsible for the variation. The sunlight regulates the temperature and also helps in the process of photosynthesis.
3. **Moisture:** It is a major limiting factor of living organisms on land specially plants and animals. Many terrestrial animals face the problem of dehydration and they develop certain devices to prevent it, though moisture still remains in the atmosphere and in the body of plants and animals.
4. **Soil:** As soil provides substratum for the plants and animals to make their home on it. It also provides nutrients for survival. The texture of the soil also varies from place to place and also flora and fauna are affected by soil conditions.
5. **Gases:** In atmosphere, oxygen and carbon dioxide gases are present. Oxygen is inhaled by the organisms and carbon dioxide is released. This carbon dioxide is utilized by the plants for the synthesis of their food and oxygen is released in the atmosphere. Thus, both these gases are important for the survival of communities on the land.

6. **Geographical barriers:** Geographical barrier is an important physical factor in the terrestrial habitat. It restricts the free movement of animals and the distribution of plants and animals on the land.

CLASSIFICATION OF TERRESTRIAL HABITATS

Ecologists and biogeographers studied the terrestrial habitats and classified them into the two regions: Realms and Biomes.

Realms: The studies of the distribution of plants and animals on the earth have revealed that there are six major biogeographic realms. These are: Australian realm, Ethiopian realm, Nearctic realm, Neotropical realm, Oriental realm, and Palaearctic realm.

Biomes: A biome is a large community unit characterized by the various kinds of plants and animals. In each biome, vegetation is uniform including grasses, conifers, and deciduous trees but the species of plants and animals vary in different parts of the biomes. The kind of climax vegetation depends upon the physical environment and the species. Ecologists have classified the biomes as: Tundra biomes, Forest biomes, Grassland biomes, Desert biomes, Wetland biomes, Mangrooves etc.

1. Tundra biomes

The word 'tundra' has been derived from the word *'tunturi'* meaning is a treeless land or marshy plain. Tundra lies largely in the north at latitude 60°N *i.e.*, between the Arctic ocean and polar ice caps and forest biomes in the south. The tundra biome is characterized by the absence of trees, the presence of dwarfed plants and its upper ground surface is wet and spongy. In tundra biome, transpiration, precipitation, and evaporation process is very slow as the highest temperature is 10°C and

precipitation is about 25 mm. The grounds of tundra usually remain in frozen state. The permanently frozen deeper soil layer is called "Permafrost". Tundra biomes cover large areas of the arctic zone. There are two types of tundra biomes: (i) the Arctic tundra and (ii) Alpine tundra. Tundra like areas are called Alpine tundra. It is quite similar to the Arctic tundra but differs in the absence of permafrost. The animals found in the tundra biome are reindeer, musk deer, the arctic hare, arctic fox, polar bear, wolves, lemmings, snowy owls, some migratory birds etc.

2. Forest biomes

A forest is any land managed for the diverse purpose of forestry which is covered with trees, shrubs, climbers etc. Forest includes uncultivated and unhabited land. Thus, the forest biome is a complex assemblage of different kinds of biotic communities. Optimum temperature and ground moisture help the trees to grow and establishment of forest communities. In addition to this, 50 mm rainfall is pre-requisite for the trees. The nature of soil, wind and air currents determine the distribution of forest vegetation. Ecologists classified the forest biomes of the world into following 4 types:

Coniferous forest biomes, Deciduous forest biomes, Temperate forest biomes, and Tropical forest biomes.

A. **Coniferous forest biomes:** The coniferous forests are characterised by the cold regions, with high rainfall and strongly seasonal climates with long winters and fairly short summer. The northern range of coniferous forest is referred as Taiga. It is characterized by the evergreen plant species such as spruce and pine trees. Animals include snow shoehare, wolf, bears, red foxes, porcupines, squirrels, amphibians like *Hyla* and *Rana tigrina* etc. Large-sized animals found in coniferous forest are reindeer, bear, beaver and several species of large

birds. In these forests, the species diversity is low, and pure stands of trees, and shrubs are common. Understory trees are uncommon which result in low penetration of light.

B. **Deciduous forest biomes:** The deciduous forest biomes are characterized by the moderate climate and the broad leaved deciduous trees. These forests shed their leaves in fall season and grow new foliage in the spring. The deciduous forest biomes are found in North America, Europe, Eastern Asia, Chile, part of Australia and Japan. Temperature of these forest biomes is 10° to 20°C and annual rainfall is 75 cm to 150 cm. Prominent plants of these biome are maple, beech, oak, hickory, basswood, chestnut, cotton wood, sycamore, elm and willow. Shrubs and herbs are well developed and richly diversified.

Animals found in the deciduous forest biomes are deer, squirrels, gray foxes, wild monkeys, and wood peckers. Invertebrates include earthworms, snails, millipedes etc. Vertebrates like amphibians such as newts, salamanders, toads and cricket frogs; reptiles such as turtles, lizards and snakes; mammals such as racoon opossum, pigs, mountain lions etc.; birds such as horned owl, hawks etc. are found. All these animals and plants show a profound seasonality. Some animals hibernate during winter. The dominant carnivores are foxes, wolves and mountain lions. Diversity of fauna is lower than any rain forest and a few species are to be dominant.

C. **Temperate forest biomes:** The temperate forest biomes are cold in nature and possess a definite seasonality. Temperature and rainfall of these forest vary throughout the year. Rainfall is high and fog is very heavy. The biodiversity of plants and animals is low. The dominant trees found are coast redwood of Pacific coast of North America and the Alpine ash of Australia and Tasmania. The animals of

temperate forest biomes are similar to those of deciduous forests, but show a somewhat higher diversity.

D. **Tropical forest biomes:** The tropical forest biomes occur near the equator in central and south America, central and western Africa, south-east Asia, New Guinea and north-west Australia. Temperature and humidity are high and constant. Annual rainfall is 200 cm to 225 cm. Mostly these forests have diverse communities. The flora and fauna of tropical forest biomes vary. The flora is highly diversified. The extremly dense vegetation remains vertically stratified with tall trees often covered with pines, creepers, lianas, epiphytic orchids and bromelids. A dense canopy also occurs all most every time. Nearly all plants are evergreen. The leaves of most of the plants are of moderate size, leathery and dark green. Fauna includes both invertebrates and vertebrates. Invertebrates density and abundance is very high while vertebrates are diverse and they are not that abundant. The common invertebrates of these forests are worms, snails, millipedes, centipedes, scorpions, spiders, insects, leeches, planarians etc., while vertebrates include arboreal amphibians, aquatic reptiles, chameleons, geckoes, and a variety of snakes, birds, and mammals. Nocturnal animals includes insectivores, leopards, jungle cats, monkeys and sloths. Tigers, elephants, sambhars, deers, chittals or spotted deers, swamp deers are the major ground dwelling mammals.

In India, patches of rainforest are found in Kerala, Assam and Orissa. The rainforests of India are of 3 types *viz.*, Moist tropical forest, Montane subtropical forest, and Montane wet temperate forests.

I. **Moist tropical forests:** These forests are wet evergreen forests and found in Assam, West Bengal and Andaman.

II. **Montane subtropical forests:** These forests are broad leaved wet hilly forests in Assam, West Bengal, Orissa and Kerala. The forests of Uttar. Pradesh and Haryana are the best examples of such forests.

III. **Montane wet temperate forests:** These forests include the forests of Kodai canal and Udagamandalam in Tamilnadu and Kerala. West Bengal and the Himalayan moist temperate forests are also good examples.

3. Grassland biomes

Grassland biomes occupies 20% of earth's land. The grassland biomes are reported to have 25 to 75 cm annual rainfall. Typical grasslands occur in the interior continents including the tall grass prairies, short grass prairies, arid grasslands of North America as well as Steppes of Eurasia (Southern Russia, Siberia and Asia), Puszta in Hungry and Veldt of Africa and Pampas of South America (Argentina). These biomes are open land communities with limited moisture conditions, irregular rainfall, very high radiation, sharp seasonal and diurnal variations. Vegetation of grassland biomes is dominated by grasses, legumes and composites. They also provide a natural pasture for grazing animals (herbivores) which are excluded from predation by predators and hide in thick vegetation. There are three types of grasslands as follows: Tropical grasslands, Temperate grasslands, and Alpine grasslands.

I. **Tropical grasslands:** These grasslands are situated at 20° away from the equator and annual rainfall varies from 40 cm to 100 cm. The length of grasses vary from 1.5 cm to 3.5 m. Example of tropical

grassland is Africa's tropical grassland. In this type of grassland, ungulates, deers, antelopes, lions and giraffes are found.

II. **Temperate grasslands:** Rainfall of temperate grasslands is 25 cm to 75 cm per year and they are found in Europe, Asia and North America.

III. **Alpine grasslands:** These grasslands occur at high latitudes. They are of meado type and many flowering herbs grow in Alpine grasslands.

Typical animals of grasslands are quite small, with few very large cursorial herbivore mammals such as bison, ponghorns, wild horses, asses and saiga antelopes of Eurasia, zebra and antelopes of South Africa. The large herbivores are no where. Similarly, carnivores are relatively small including weasels, badgers, foxes, owls and rattle snakes etc. Rodents such as prairies dogs, rabbits, and ground squirrels are common. Most herbivores are found in herds or colonies. The characteristic birds of grassland biomes are prairies chickens, meadow larks. Mammals include rabbits, rats and Kangarooss and insects are grasshoppers and crickets. Thus, the grasslands have a characteristics fauna.

4. Desert biomes

These are the largest biomes and are formed due to the dried environments. Temperature of desert biomes is highly variable and moisture contents is very low. There are two types of deserts *viz.*, hot and cold deserts.

A. **Hot deserts:** Temperature of the hot deserts is very high. Major hot deserts of the world are situated near the tropics of cancer and capricon, with rainfall less than 10 mm. The most important hot deserts in the world is the group of Sahara-Arabia-Gobi deserts complex which extends from Africa to Central Asia and contain highly irregular and very insignificant rainfall, and low humidity is due to the excessive

evaporation. Hot deserts occurs in India (Sindh-Rajasthan deserts), South America (Chile), North America and Australia.

B. **Cold deserts:** Temperature of the cold deserts is very low and these deserts occurs at high elevations where the temperature is low and rainfall is scanty. Cold deserts reported in Laddakh region of Himalayas, Tibet and Bolivia Arctic.

Both hot and cold deserts are distinguished by the difference in plants which are mostly succulent type *e.g.*, cactus, pal verde trees, creosote brush etc. Most of the cold deserts have sage brush. The flora of hot deserts include cacti, water storing succulents such as acacias, euphorbias, prickly pears etc. The fauna of desert biomes include reptiles, insects and burrowing rodents. All these animals possess special morphological, physiological and ethiological adaptations for deserts. In general, the large animals are very uncommon except mul deer and some species of gazelle. All these animals have cursorial, fossorial and saltorial adaptations. Some animals are adapted for extreme high temperatures. The camel and desert birds (*e.g.*, Ostrich) have an occasional drink of water but can go for long periods using the water stored in the body. Most of the insects in deserts are herbivores. The flora and fauna of Indian deserts is optimum and diverse type. All these animals are adapted for survival at extremly high temperature and low humidity. Many of them possess diurnal rhythmic activities.

5. Wetland biomes

The wetland biomes are submerged or water saturated lands. These lands may be natural and artificial, may be temporary or permanent type. Generally, the wetlands are seasonal *i.e.*, with free overlying water in the rainy season, marshy and often almost dry in summer season. Wetlands are swamps, marshes, fens, peat lands, lagoons, lakes etc.

The wetland biomes have specialized vegetation and fauna. They are suitable as niche for fish and other aquatic fauna, as breeding and nursery grounds for water fowls and as filters for sediments and pollutants. Flood plains and marshes are good examples of wetlands and serve as secure places for many kinds of wild life. Sunderbans is one such habitat in the coastal belt of Bay of Bengal. In many parts of the world, the wetland biomes are disappearing very fast due to the dumping of wastes and reclamation for agriculture, housing, forest etc. Some lotic type wetlands are polluted by the city sewage, industrial effluents and runoff pesticides and other agrochemicals applied in the croplands.

6. Mangroves

These are halophytes growing in muddy swamps of the estuaries of tropical and sub-tropical regions. The sea coasts flooded due to the rivulets and tides form mangroves. Mangroves comprise of swamps and forest lands within its water spread areas. In India, the total mangrove area is 6740 sq. km which is nearly 7% of the world's total mangroves. The well known mangroves areas are Sundarbans in West Bengal and Andaman and Nicobar islands. Both these mangroves are occuping in a area upto 80% and remaining 20% in Karnataka, Andhra Pradesh, Tamilnadu, Kerala, Goa etc. The flora and fauna of mangroves is diverse. Fauna includes snakes, lizards, turtles, jackals, wild boars, hyaenas etc. In the mangrove of coast of Orissa, sea turtles also found. Mangroves areas have high productivity. Similarly, the secondary productivity and decomposition activity are also high. It is reported that in recent years, the Indian mangroves have been subjected to reckless exploitation and other biotic interference.

QUESTIONS

1. Discuss the terrestrial habitats in India.
2. What are the factors affecting the terrestrial habitats?
3. How the terrestrial habitats are classified?
4. What is the difference between realms and biomes?
5. Explain the following biomes with their flora and fauna:
   I. Grassland biomes
   II. Desert biomes
   III. Forest biomes, and
   IV. Wetland biomes.
6. Write short notes on:
   A. Realms
   B. Biomes
   C. Tundra biomes
   D. Mangroves

12

NATIONAL PARKS AND SANCTUARIES

India is a land of fascination wilderness manifested in various species of animals and birds found in the country. The national parks are set up for preserving the flora, fauna, landscape and historic objects of an area. India's first national park, 'Hailey national park' now known as 'Jim Corbett national park' was established in 1935. By 1970, India enacted the wild life protection act and Project Tiger to safeguard habitat was launched. In 1980, Federal legislation strengthening the protections for wild life was introduced. In April, 2007, there were 96 national parks in India. Total national park land encompass is 38,029.18 km^2 *i.e.*, 1.16% of India's total surface area. Now a total of 166 national parks have been estiblished. Plans are underway to establish more national parks.

The sanctuaries contains some of the rare species in the world. They play an important role in protecting the rare species from the poachers. They provide safe heavens away from the unscrupulous animals traders, who sell the body parts of the animals at fabulous price to interested parties for medicinal or other purposes.

IMPORTANT NATIONAL PARKS AND SANCTUARIES

Some of the important national parks and sanctuaries of India are given here with their state, year of establishment and area covered (Table 12.1). Some of the national parks have been described below.

Table 12.1. List of important National Parks in India

National Parks	State	Year	Area (km^2)
Bandhavgarh National Park	Madhya Pradesh	1982	448.85
Bandipur National Park	Karnataka	1974	874.20
Bannergatta National Park	Karnataka	1974	104.27
Bori Wildlife Sanctuary	Madhya Pradesh	1965	518.00
Chandoli National Park	Maharashtra	2004	308.97
Jim Corbett National Park	Uttarakhand	1936	520.82
Gir National Park	Gujarat	1975	258.71
Hazaribag National Park	Jharkhand	1976	183.89
Kanha National Park	Madhya Pradesh	1955	940.00
Kaziranga National Park	Assam	1974	471.71
Kuno Wildlife Sanctuary	Madhya Pradesh	1981	344.65
Madhav National Park	Madhya Pradesh	1959	375.22
Manas National Park	Assam	1990	500.00
National Chamble Wildlife Sanctuary	Madhya Pradesh	1979	5400.00
Panna National Park	Madhya Pradesh	1973	542.67
Pench National Park	Madhya Pradesh	1975	292.85
Pench National Park	Maharashtra	1975	257.26
Periyar National Park	Kerala	1982	350.00
Ranthombor National Park	Rajasthan	1980	392.00
Salim Ali National Park	Jammu and Kashmir	1992	9.07
Sanjay Gandhi National Park	Chhattisgarh	1981	1471.13
Sanjay Gandhi National Park	Madhya Pradesh	1981	466.88
Sanjay Gandhi National Park	Maharashtra	1983	86.96
Satpura National Park	Madhya Pradesh	1981	585.17
Silent Valley National Park	Kerala	1984	89.52
Simplipal National Park	Orissa	1980	845.70
Sundarban National Park	West Bengal	1980	845.70
Tadoba National Park	Maharashtra	1955	116.55
Valley of Flowers National Park	Uttarakhand	1982	87.50
Van Vihar National Park	Madhya Pradesh	1979	4.45

1. Gir National Park

Gir national park is the sole home of the pure Asiatic lions (*Panthra leo persica*). It measures about 258 km^2 for the national park and 1153 km^2 for the sanctuary. It was established in 1965. Its total area is 1411 km^2 located about 65 km to the south-east of Junagarh city of the Gujarat.

The flora and fauna of Gir forest is diverse and is protected. As per the census recorded in April 2005, the total lions count was 359. The lion breeding programme covering the park and surrounding area has bred about 180 lions in captivity since its inception. The park and sanctuary remain open throughout the year but peak period for tourists is November and early March. During this period, it is easier to sight the wildlife in the open.

The flora of Gir forest includes more than 400 plant species which were recorded in the survey. Gir forest is the largest dry deciduous forest in western India. Teak bearing area is mainly in the eastern portion of the forest. This forest is an important biological research area with considerable scientific, educational, aesthetic and recreational values. The forest provides nearly 15,000 metric tons worth of fuel wood annually.

The fauna of Gir national park includes 2,375 distinct species of animal including 38 species of mammals, 300 species of birds, 37 species of reptiles and more than 2000 species of insects. Some of the important mammals found in Gir national park are Asiatic lions, leopards, jungle cats, jackals, mongoose, desert cats etc. Herbivores of Gir are Chital, Nilgai (bluebull), sambar, 4- horned antelope, chinkara and wild boar. Among the small mammals, porcupine and hare are common but pangolin is rarely found. Reptilians includes marsh crocodile, Indian star tortoise and the monitor lizard. Pythons and other snakes are also reported. The plentiful

avifauna includes more than 300 species of birds, most of which are resident. Important birds found in Gir are eagle, owl, bush quail, wood pecker, etc.

2 Hazaribagh National Park

The Hazaribagh national park is 135 km from Ranchi, Bihar state, also a sanctuary adorned with scenic beauty. It is 19 km from Hazaribagh town. The park has tigers, panthers, sambhars and wild boars can be seen easily. Only 25 tigers were present as per the census of 2005. The tigers are really difficult to sight. The Hazaribagh sanctuary is surrounded by tribal habitation. There are many watch towers to see the wildlife in its true natural habitat.

3. Kaziranga National Park

Kaziranga national park is in the Golaghat and Nagaon districts of Assam. It is located between latitude 26°30' N and 26°45' N and longitude 93°08' E to 93°36' E and covers an area of 378 km^2. It was established in 1905 and is oldest one in India. It has been the theme of several books, documentaries and songs. The park area is circumscribed by the Brahmaputra river. Other notable rivers in the park are Diphlu and Mora Dhansiri.It is a world heritage site, and 2/3 of the world's great one horned Rhinoceroses live in the park. Kaziranga has highest density of tigers among the protected areas in the world and was declared as a 'Tiger Reserve' in 2006. The park has large breeding populations of elephants, water buffaloes and swamp deers. Kaziranga is recognized as an important bird area also. The Kaziranga park has achieved notable success in wildlife conservation as compared to other protected areas in India.

The flora includes the four main types of vegetation *viz.*, alluvial inundated grasslands, alluvial savana

woodlands, tropical moist mixed deciduous forests and tropical semi-evergreen forests. Dominant species include kumbhi, Indian gooseberry, the cotton tree and elephant apple. There is also aquatic flora in ponds, lakes and river shore.

The fauna of Kaziranga national park contains significant populations of 35 mammalian species; of which 15 species are threatened. Mostly, the great Indian one horned Rhinoceros, wild Asiatic water buffaloes, Eastern swamp deer, elephants, gaur, sambhar, wild boar, hog deer etc. are found.

Kaziranga has been identified by bird life International as an important bird area. It is home to a variety of migratory birds, water birds, predators, scavengers and game birds. Kaziranga was one home to seven species of vultures but now they are near to extinction. Other birds inhabiting Kaziranga are the Great Indian hornbill and Wreathed marsh babblers, weaver birds etc. Other threatened species includes Black breated parrotbill and Rufous-vented prinia.

The species of python includes the reticulated python, rock python inhabit the park. Other snakes found here include Indian cobra, monocied cobra, Russel's viper and common krait. Monitor lizard is also found. Other reptilian species include 15 species of turtles and one species of tortoise, 42 species of fishes are also reported.

4. Ranthambore National Park

Ranthambore national park is one of the largest and most famous national park in northern India. It is located in Sawai Madhopur district of south-eastern Rajasthan; 130 km away from Jaipur, and 11 km away from Sawai Madhopur. It is established in 1980, covering an area of 392 km^2. The park lies at the edge of a plateau, bounded

in the north by the Banas river and in South by the Chambal river. The park has several lakes in side.

Ranthambore national park is famous for its tiger population, and is one of the India's famous Tiger reserves. The flora includes trees and plants, largest Banyan trees in India are also reported. The fauna includes tiger, leopard, nilgai, dhole, wild pig, sambhar and chital.

5. Sundarban National Park

The Sundarban national park, tiger reserve, UNESCO'S world heritage site and a biosphere reserve is located in the Sundarban delta of West Bengal. The word 'Sundarban' in the Bengali language literally means 'beautiful jungle' or 'beautiful forest'. The name Sundarban is derived from the 'Sundari trees', which are found in Sundarban in large numbers.

Geographically, Sundarban national park is located in between 30° 24' - 30° 28' N longitude and 77° 40' - 77° 44' E latitude in the south 24 Paragana district of West Bengal. The height of the park is 7.5 m above sea level. It is made up of 54 islands and is criss crossed by several tributaries of river Ganga. Sundarban national park is the largest estuarine mangrove forest in the world. Here the temperature ranges from 20° to 34° C, humidity is 80% and rainfall is heavy. The Directorate of Forest, West Bengal State Government is responsible for the management of Sundarban. Its headquarter is at Canning town. It was established in 1973 and covers 16,902 km^2 area.

The flora of Sundarban national park includes the densely covered mangrove forests, with 64 plant species. The commonly found plants and trees in the park are genwa, dhundal, passur, garjan, kankra, sundari and goran.

The fauna includes more than 200 tigers. The Royal Bengal tigers have developed a unique characteristics of swimming in saline waters, and are world famous for their man eating tendencies. Apart from this, fishing cats, macaques, wild boar, common grey mongoose, fox, jungle cat, flying fox, pangoline and chital are found in abundance in the Sundarbans.

The avifauna of Sundarban includes many species of birds including open billed strokes, white ibis, water hens, coots, kites, swamp patridges, red jungle fowls, spotted doves, kingfishers, plovers, green pigeons, eagles etc.

Aquafauna include crustaceans fishes amphibians and mammals in the park. They are sawfish, butterfish, electric rays, silver carp, starfish, common carp, king crabs, prawns, shrimps, Gangetic dolphins, skipping frogs, common toads, and tree frogs. Reptiles of Sundarban are olive turtles, green turtles, estuarine crocodiles, sea snakes, dog faced water snakes, chameleons, king cobras, Russel's vipers, pythons, common kraits, and rat snakes.

The endangered species of Sundarban are Royal Bengal tigers, estuarine crocodiles, olive turtles, Gangetic dolphines, ground turtle, king crabs (Horse shoe crab), and river terrapin.The ideal time to visit the park is between November to mid-Febrauary when the tiger can be seen on the river banks having sunbath.

6. Simlipal National Park

Simlipal national park is a tiger reserve situated in the Mayurbhanj district of Orissa. The name Simlipal national park is derived from the magnificent Simili (Silk Cotton trees) trees. The park was established in 1980 with an area of 845.70 km^2. It has some beautiful water falls like Joranda and Barehipani. The park is famous for its tigers, leopards and elephants, hill maynah and orchids. Climate

of Simlipal national park is very hot, temperature ranges from 14°C to 40°C and rainfall is from heavy to moderate.

The flora of this national park is very rich having 1076 species of plants belongs to 102 families. 92 species of orchids are also seen. The mixed type vegetation, grassland and savana's provide grazing grounds for herbivores and hiding places for carnivores. The medicinal and aromatic plants provide as an eating source for tribal people.

The fauna includes 42 species of mammals, 242 species of birds and 30 species of reptiles in the Simlipal national park. The major mammals are tiger, leopard, elephant, sambhar, barking deer, bison, jungle cat, wild boar, 4-horned antelope, giant squirrel and common langur. The avifauna includes 231 species of birds. Reptiles found are snakes, turtles and crocodiles.

The nearest railway station for Simlipal national park is Baripada (17 km away from Pithabata, the entry point). One can enter into the national park through Pithabata and Jashipur. The national park remains open from 1 November to 15 June only.

7. Tadoba National Park

Tadoba - Andhari tiger reserve is a tiger reserve in Chandrapur district of Maharashtra. It includes Tadoba national park and Andhari wildlife sanctuary. It is an oldest national park in Maharashtra, established in 1955, covering an area of 623 km^2. It is one of the India's 28 tiger reserve. Around 50 tigers are found and also home for rare Indian wildlife like leopards, sloth bears, wild dogs, hyenas, jungle cats, and many species of Indian deers like sambhar, cheetal, nilgai, and barking deer. Tadoba national park is famous for marsh crocodile. It is also an ornithologists paradise with a diverse fauna of birds.

Tadoba national park is approximately 45 km away from Chandrapur, and 200 km away from Nagpur. The park remains closed on every tuesday.

8. Jim Corbett National Park

Jim Corbett national park is an oldest national park in India. It was established in 1936 as Hailey national park, covering an area of 323.75 Km^2. But in 1955, the park was renamed as 'Jim Corbett national park'. The new name honours the well known author and wildlife conservationist, Jim Corbett who played a key role in the establishment of park. It is situated in Naini Tal district of Uttarakhand.

Geographically, the park is located between 29° 25' to 29° 39' N latitude and 78° 44' to 79° 07' E longitude. Its height from sea level ranges from 380 to 1,040 m. It has numerous ravines, ridges, minor streams and small plateaus with varying aspects and degree of slopes. The park has sub-Himalayan belt with geographical and ecological characteristics. Temperature of the park ranges from 5° C to 40° C and rainfall ranges from light during dry season and heavy during monsoon.

The flora of the park includes 488 different species of plant. Tree density inside the park is higher as Sal forest is quite thick and lowest because of *Anogeissus-Acacia catechu* forests. The park is dominated by trees of Sal. Other trees include Jamun, *Malloptus philippinensis* and *Diospyros tomentosa* communities.

The fauna of national park possesses more than 585 species of resident and migratory birds including crested serpent Eagles, blossom headed parakeet and the red jungle fowl-ancestor of all domestic fowls. 33 species of reptiles, 7 species of amphibians, 47 species of fish and 37 species of dragonflies have also been recorded.

Bengal tigers, although plentiful, are not easily spotted due to the abundance of camouflage in the reserve. Leopards are found in hilly areas. Other mammals including four kinds of deers (barking, sambhar, hog, black buck and chital). Sloth and Himalayan black bears, Indian grey mongoose, otters, pangolins, langur and Rhesus Macaque are also occurring. Owls and nightjars can be heard during night. During summer, elephants are seen in herds of several hundred. The Indian python is also found, capable of killing a chital deer. Local crocodiles can also be saved from extinction under captive breeding programme.

According to Tiwari and Joshi (1997), summer (April-June) is to be the best season for Indian tourist to visit the parks and winter (November to January) for foreign tourists. Riley and Riley (2005) have reported that best chances of seeing a tiger are late in the dry season *i.e.*, from April to mid-June and to go out with mahouts and elephants for several days. The increase in tourist activities, among other problems, continues to present a serious challange to the park's ecological balance.

9. Sanjay Gandhi National Park

The Borivali national park is officially known as Sanjay Gandhi national park. It is an unique national park, lying along the borders of Mumbai city. It encompasses an area of 104 km^2. It is one of the Asia's most visited national parks with 2 million annual visitors. The park also holds claim to be the largest park in the world located within the city limits. Within the park, ancient Kanheri caves dating back 2400 years were sculpted out of the rocky cliffs. The park has rich flora and fauna.

Geographically, the park is located in the sub-urbs of Mumbai. It occupies most of the northern sub-urbs. The region is hilly with a maximum height of about 400 m.

The park comprises 2 lakes: Vihar lake and Tulsi lake. They purify most of the pollution of the city.

The park is a bustling forest, dense forest. Around 800 species of flowering plants are noted in the park. The fauna includes 284 kinds of birds, 5000 species of insects, 150 species of butterfly, 36 types of mammals and 50 reptiles. It has also many endangered species of plants and animals. Chital or spotted deer, Rhesus macaque and Bonnet macaque are some of the wild animals which can easily observed in the park. Other animals include Indian hare, barking deer, porcupines, Asian palm civet, Mouse deer, Hanuman (Grey) langoor, Indian flying fox, sambhar, crocodiles, pythons, cobras, monitor lizards, dobia (Russel's viper), cat snake and pit viper are noted creatures of the park. Jain temple,Taramati temple, Omkareshwar temples are located in the Park. The park has faced a number of problems involving conflict between nature and human activites. In June 2004, leopards were responsible for the death of 20 human beings. Out of these, 8 leopards were caught and relocked.

10. Periyar National Park

Periyar national park is a protected area, set high in the mountains of the western ghats at the border of Tamilnadu. Periyar national park lies in Idukk and Pathanamthitta districts of Kerala. It was established in 1982, covering an area of 305 km^2 (total area 777 km^2). Nearest city is Kochhi (120 km). The park is often called by the name of "Thekkady".

The flora of Periyar national park includes tall tropical species such as *Vateria indica, Cullenia exarillata, Hopea purviflora, Canarium strictum, Artocarpus hirsutus* and *Bischofia javanica*. They reach upto the height of 40 to 50 meters. Nearly 2000 kinds of flowering plants are reported. Among the angiosperms, 169 families of sweet grasses and

155 kinds of fabaceous plants are noted. Around 350 plants are used for medicinal purposes.

The fauna of Periyar national park is rich including 62 species of mammals like Indian elephants (900 to 1000 individuals), gaur, sambhar, barking deer, mouse deer, wild dogs, mongoose, foxes and leopards, Nilgiri tarh. Four species of primates are found in Periyar *viz.*, the lion - tailed macaque, the Nilgiri langur, the common langur and the Bonnet macaque. Avifauna includes 320 different kinds of birds. These are darters, cormorants, kingfishers, the great Malabar hornbill, and rocket tailed drongoes. 45 species of reptiles are found, of which 32 species of snakes, 2 turtles and 13 lizard species are reported. Sometimes python and king cobra are also seen. 27 species of amphibians, 38 species of fishes, 160 species of insects are also noted. Beside this there is also Periyar Tiger reserve, which is one of the 27 tiger reserves in India, situated in this national park.

11. Nagzira National Park

This park is situated in Bhandara district of Maharashtra. Its distance from Bhandara city is 60 km. The total area of this national park is 132 km^2. The forest area of this park is dominated by teak, bamboos, and sal. The wild fauna of this park includes tiger, leopard, wild bear, sambar, chital, blue bull, bison, sloth bear, langur and wild dogs. It is rich in both the vertebrate and invertebrate fauna.

12. Kanha National Park

Kanha national park is a national park and a tiger reserve in the Mandla and Balaghat district of Madhya Pradesh. The park was established on 1st June, 1955. Today, it stretches over an area of 940 km^2 in these two districts. Together with a surrounding buffer zone of 1,009 km^2 and

the neighbouring 110 km^2 Phen sanctuary, it forms the Kanha tiger reserve. The park has a significant population of Royal bengal tigers, leopards, sloth bear, baraha singha, gaur (bison) and Indian wild dog.

The flora of Kanha national park is a mixture of Sal and other forest trees, interspersed with meadows. The highland forests are tropical moist dry deciduous type and are of completely different nature with bamboo plants on slopes. The Indian ghost tree (Kullu) can also be seen in the dense areas. Aquatic plants, numerous in lakes, are life line for many migratory birds and wetland species of birds.

For reaching the national park, Jabalpur is the nearest aerodrome (169 km) which is connected with Delhi, Mumbai, and Bhopal. Mandla is having sport clubs, internet cafe, guides, churches, and hundreds of beautiful temples around the city. The Kisli gate is best accessible from Jabalpur and the second gate is Mulkki. The Kisli gate stops at village Khatia which comes inside the buffer area.

13. Madhav National Park

Madhav national park is situated in Shivpuri district of Gwalior region in north-west Madhya Pradesh. Shivpuri town is located at 25° 40' north, 70° 44' east on Agra - Mumbai national highway no. 3. Earlier its dense forests were the hunting grounds of the Mughal emperors. Total area of this national park is 354 km^2. It was set up in 1959. This national park has a varied terrain of forested hills and flat grassland around the lake. It is very rich in biodiversity. It remains open throughout the year. The principal tree species found in the park are Khair, Salai, Kerdhai, Dhawala, Tendu, Palash etc. The prominant wild animal species found in the park are deer, chinkara or Indian gazelle and chital. Other species inhabit the park are nilgai, sambar, chausingha, blackbuck, sloth bear, leopard and the common langur.

Madhav national park is equally rich in avifauna. Frequently spotted birds are red-wattled lapwing, large pied wagtail, Indian pond heron and white treasted kingfisher. The park's avifauna also includes the cormorant, painted stork, white ibis, laggar falcon, purple sunbird, Asian paradise flycatcher and golden oriole.

14. Bandhavgarh National Park

Bandhavgarh national park is one of the large national park in India, located at the Umaria district of Madhya Pradesh. Bandhavgarh was declared as a national park in 1968 with an area of 105 km^2. The buffer zone is spread over the forest division of Umaria and Katni and total area is 473 km^2. The park derives its name from the most prominant hillock of the area, which is said to be given by Lord Rama to his brother Laxman to keep a watch on Lanka. Hence, the name Bandhavgarh which means 'Brother's fort'. This park has a large biodiversity. The density of the tiger population at Bandhavgarh is quite rich. This park has number of large species of deers.

15. Satpura National Park

Satpura national park is located in the district Hoshangabad of Madhya Pradesh. It gets the name from Satpura hill ranges (Mahadeo hills). It covers an area of 524 km^2. Satpura national park along with Bori and Panchmarhi sanctuaries provide 1427 km^2 of unique Central Indian highland ecosystem. It was set up in 1981. The nearest town to the national park is Panchmarhi and the nearest railway station is Piparia at a distance of 55 km. Satpura national park is rich in biodiversity. The flora includes mainly Sal, Teak, Tendu, Amla, Mahua, Ber, Bamboo, and a variety of grasses and medicinal plants. The fauna comprise of tiger, leopard, sambhar, chital, nilgai, bhedki, chinkara, four horned antelope, bison, wild boar, wild dog, bear, blackbuck, fox, porkupine, flying

squirrel, mouse deer, Indian joint squirrel etc. The avifauna is also rich and there is a variety of birds. Hornbills and peafowl are the common birds.

16. Panna National Park

Panna national park is located in the Chhatarpur district of Madhya Pradesh. It has an area of about 1,406 km^2. Among the animals found here are the chital, chinkara, sambhar and sloth bear. It is also a tiger reserve. The park is home to more than 200 species of birds including bar headed goose, honey buzzard, king vulture and blossom headed parakeet.

17. Sanjay National Park

The Sanjay national park is located in the Madhya Pradesh. Its headquarter is at Sidhi. It covers an area of 466.8 km^2. The flora of the national park is mostly composed of Sal forest. The fauna includes tiger, leopard, chital, sambhar and nilgai; wild boar is also found here.

18. Pench National Park

Pench national park is situated in Seoni and Chhindwara districts of Madhya Pradesh. The name derived from the Pench river that flows through the national park. It was declared a sanctuary in 1977 but raised to the status of national park in 1983. Later, it was established as tiger reserve in 1992. The area of national park is 293 km^2. The terrain of Pench is covered with small hills and well stocked teak mixed forest in the southern reaches of Satpura ranges. The forest cover in the park area includes grand teak, mixed with other magnificant species like saja, bija, lendia, haldu, salai, donla, amaltas, etc. The ground is covered with maze of grasses, plants, bushes and saplings. Bamboo is also found at some places. Dazzling white Kulu trees are scattered around stand.

Tiger is an animal of cat family in the park and is found in good numbers. Commonly seen wild life includes chital, sambhar, nilgai, wild boar and jackal. Other wild animals are leopard, sloth bear, wild dog, porcupine, jungle cat, fox, striped hyena, gaur, chausingha and barking deer. There are 170 species of birds including several migratory ones. Some of them are pea fowl, jungle fowl, crow phaesant, crimson-breasted barbet, sed vented bulbul, racket tailed drongo, magpie robin, pintail, shoveler, herons etc.

19. Van Vihar National Park

Van Vihar national park is located at the heart of Bhopal, Madhya Pradesh. It is established in 1933, covering an area of 445 km^2. This national park is managed as a modern zoological park, following the guidelines of the Central Zoo Authority. The animals are kept in their near natural habitat. Most of the animals are either orphaned, brought from the various part of the state or exchanged from other zoos. Van Vihar is situated at the foot of the Shyamla hills, which is one of the several hills constituting the topography of Bhopal.

Van vihar categorises the animals in two categories *viz.*, carnivores and herbivores. All carnivorous animals are kept inside the enclosed areas and herbivores are allowed to roam freely. The animals such as tiger, panther, lion, boar, hyena etc. are kept in the captivity. Free ranging animals such cheetal, sambar, blue bull etc. which is an unique feature of Van vihar. Van vihar also preserves the animals belonging to endangered species.

The wildness of the park offers an ideal habitat for a number of avian fauna, till now around 200 species of birds are reported. This park is also abode of variety of butterflies and insects.

20. National Chambal (Ghariyal) Wildlife Sanctuary

The National Chambal (Gharial) wildlife sanctuary in India was founded in 1979 and is a part of large area co-administered by the State Government of Rajasthan, Madhya Pradesh and Uttar Pradesh, within an area of 5400 km^2. along the Chambal river. Approximately 400 km of the river is within the reserve, forming the core area. Apart from the Gangetic Dolphin, the other inhabitants of the sanctuary include Magar (Crocodile) and Ghariyal (*Gavialis gangeticus*). Stretch of crystal clear water also supports marsh crocodile, smooth coated otters, 6 species of turtles and 250 species of birds. Migratory birds from Siberia form its rich avian fauna. One of the rare bird present here is Indian skimmers. The sanctuary is protected under India's Wild Life Protection Act, 1972. The sanctuary is administered by the Department of Forest, Government of Madhya Pradesh, under the Project Officer with head quarters at Morena, Gwalior.

21. Kuno Wildlife Sanctuary

This sanctuary or Palpur-Kuno wild life sanctuary lies in the Sheopur district of north-western Madhya Pradesh. It is about 120 km from Gwalior. An area of 344.65 km^2 was set a side as a wild life sanctuary in 1981. The sanctuary is home to many species of wild animals including wolves, monkeys, leopards, nilgai and possibly a few remaining Bengal tigers. Wildlife Institute of India researchers confirmed that Palpur-Kuno wildlife sanctuary is the most promising location to re-establish a free ranging population of the Asiatic lions and certified that it is ready to receive its first batch of translocated lions from Gir wildlife sanctuary where they are over populated.

22. Bori Wildlife Sanctuary

This sanctuary is located in Hoshangabad district of Madhya Pradesh in Cental India. The sanctuary covers an area of

518 km^2, located in the northern foot hills of the Satpura ranges. It is bounded by the Satpura national park in the north and east, and by Tawar river in the west. The sanctuary together with Satpura national park and the Panchmarhi sanctuary forms the Panchmarhi Biosphere Reserve.

The sanctuary is covered with mixed deciduous and bamboo forests. It is an important transition zone between the forests of western and eastern India. Dominant trees includes Teak, Dhaora, Tendu among others. Large mammal species include tiger, leopard, wild boar, muntjae deer, gaur, chital, Sambhar and Rhesus macaques are found.

23. Panchmarhi Biosphere Reserve

The Panchmarhi biosphere reserve is a conservation area in the Satpura range of Madhya Pradesh. It was estabhished on 3rd March, 1999 by the Government of India and covers the part of Hoshangabad, Betul and Chhindwara districts. The biosphere reserve's total area is 4926.28 km^2. It includes three wildlife conservation units *viz.*, the Bori sanctuary, Satpura national park and Panchmarhi sanctuary. The reserve is mostly covered in forest and part of the Eastern highlands moist deciduous forests eco-region. It is an important transition zone between the forests of western and eastern India. The forest is dominated by teak plants but includes the western moist groves of sal (*Shorea robusta*), which is the dominant tree of the eastern India's forest. Large mammalian animals include tiger, leopard, wild boar, muntjac deer, gaur, chital, sambhar and Rhesus macaques.

QUESTIONS

1. What do you understand by national parks and sanctuaries ?
2. Discuss the important national parks in India.

3. Describe Sanctuaries of Madhya Pradesh.
4. State the differences between national parks and Sanctuaries.
5. Write short notes on:
   A. National parks
   B. Sanctuaries
   C. Jim Corbett national park
   D. Kaziranga national park
   E. Gir national park

13

ENVIRONMENTAL DEGRADATION AND POLLUTION

Each and every living organism has its specific surroundings or medium of environment to which it continuously interacts and remains fully adapted. S.C. Kendigh (1974) defined the environment as the sum total of physical or abiotic factors and biotic conditions which is influencing the response of living organisms. The life supporting environment of the planet earth is the biosphere which is composed of three media *viz.*, air, water and soil. These are the components of atmosphere, hydrosphere and lithosphere. All these three media are not completely isolated from each other. However, some of the atmospheric gases *viz.*, SO_2, CO_2 etc. are dissolved in natural waters and some moisture is present almost everywhere in the atmosphere. Excess of these gases cause pollution and ultimately degrade our environment.

ENVIRONMENTAL DEGRADATION

Environmental degradation is one of the major threat officially cautioned by the High Level Threat Panel of the United Nations. Environment degradation means the deterioration of the environment through the depletion of resources *viz.*, air, water and soil as well as the destruction of ecosystem and the extinction of wildlife.

The World Resources Institute, the United Nations Environment Programme, the United Nations Development Programme and the World Bank have prepared an important report on the health and environment for public and declared it on 1st May, 1998. The report describes that how preventible illness and premature deaths are still occurring in large number. If the improvement is made in the human health, millions of the people will live longer and healthy life. In the poorest region of different countries, it was observed and estimated that one in five childrens will not live to see their fifth birthday only because of environment related diseases and environmental degradation. Around 11 million children die annually in the world due to malaria, acute respiratory infections or diarrhoea etc., which is equal to the combined population of Norway and Switzerland. These diseases are preventable, if we made improvement in our environment and adapted healthy living practices. Thus, environmental degradation is a serious threat to the living organisms and it is necessary to prevent the deterioration of our environment. So that the organisms on this planet earth can live longer and healthy life forever.

POLLUTION

Pollution is a serious threat to the environment because of which the environmental degradation is caused. It is the introduction of contaminants into the environment. These contaminants causes instability, disorder, harm or discomfort to the physical systems or living organisms. Pollution is caused mainly due to pollutants as chemical substances, energy such as noise, heat or light energy. The term 'Pollution' is extended as any substance when it occurs at higher concentration within a system and create danger to that system *e.g.*, water, air or land which is essential for the life, and if it is polluted due to the higher concentration of pollutants. The polluted water drunk in an excessive

quantity, then the physical system of man would become so over burdened that could result into breakdown and even death. Other example of pollution is the potential of excessive noise to introduce imbalance in a person's mental state, resulting in malfunction and psychosis.

The major forms of pollution are air pollution, water pollution, soil contamination, radioactive contamination, noise pollution, light pollution, visual pollution, and thermal pollution etc.

The Blacksmith Institute issues annually a list of the World's worst polluted places. In 2007, this Institute issued the top ten nominees located in India, China, Russia, Peru, Azerbaijan, Ukrain and Zambia.

Sources and causes of pollution

The sources and types of pollution are enumerated here.

1. Motor vehicle emissions is one of the leading cause of air pollution.
2. The more common soil contaminants are chlorinated hydrocarbons, heavy metals, pesticides and benzene etc.
3. In case of noise pollution, the dominant source is motor vehicle.
4. Pollution can also be the consequence of a natural disaster *e.g.*, huricanes which involve the water contamination from sewage, and petrochemical spills from ruptured boats or automobiles.

Effects of pollution

1. The pollution cause adverse effects on the health of human being. The polluted air can kill many organisms including man. Ozone pollution can cause respiratory diseases, cardio-vascular diseases, throat inflammation, chest pain, etc.

2. Water pollution causes many diseases *viz.*, cholera,diarrhoea, typhoid and even sometimes may cause death. All these diseases are mostly due to the contamination of drinking water by untreated sewage in the developing countries.
3. Noise pollution may cause the loss of hearing, high blood pressure, stress and sleep disturbances.
4. Oil spills can causes skin irritation and rashes.

Without pollution control, the waste products from the urbanization, heating, agriculture, mining, manufacturing, transportation and other human activities will degrade the environment, whether, they accumulates or disperse. The term pollution control is used in environmental management which means the control of emissions and effluents in the air, water, and soil. There are many devices for the control of pollution. These are mentioned here-

1. **Dust Collection Systems:** These are cyclones, electrostatic precipitators and bag houses.
2. **Scrubbers:** These are baffle spray scrubber, cyclonic spray scrubber, ejector venturic scrubber, and mechanically aided scrubber, etc.
3. **Sewage treatment and wastewater management:** API oil-water separators, sedimentation, dissolved air flotation (DAF), activated sludge biotreators, biofilters, and powered activated carbon treatment are such devices.
4. **Vapour recovery systems:** To protect the environment from the environmental degradation and the adverse effects of the pollution, many nations worldwide have enacted legislation to regulate various types of pollution as well as to mitigate the adverse effects of local and global pollution and an increasingly informed public has given rise to environmentalism and the environmental

movement, which generally seek to limit human impact on the environment.

Thermal pollution

Temperature is one of the important abiotic factor. If its range increases or decreases, it severally effects the living organisms. The pollution caused by the change in temperature is referred to be thermal pollution. It may be defined as, the temperature changes in natural water bodies and atmosphere caused due to the human activities. Such pollution is known as 'Thermal pollution'. The change in temperature may be upward or downward.

Sources

In the Northern hemisphere, the source of thermal pollution is the use of water as coolant, especially in power plants. Water used as coolant is returned to the natural environment at a higher temperature. Increase in water temperature can have impact on the aquatic biota by decreasing dissolved oxygen concentration, by killing the fish juveniles which are vulnerable to small fluctuations in the temperature, and by affecting the ecosystem composition.

In Southern hemisphere, the thermal pollution is commonly caused by the release of very cold water from the base of reservoirs, with severe effects on fishes, particularly eggs and larvae, macro-invertebrates and river productivity.

Effects

The effects of thermal pollution have been studied under two heads: Ecological effects of warm water, and ecological effects of cold water.

1. **Ecological effects of warm water:** Typically the warm water decreases the level of dissolved oxygen

in the water. The decreased level of dissolved oxygen can make harm to the aquatic animals *viz.*, fishes, amphibians and copepods. The thermal pollution also increases the metabolic rate of aquatic animals which result into the consumption of more food in short time, if their environment is not changed. Changes in the environment may also results in the migration of organisms and may decrease the biodiversity. It was studied and found that even slight change in temperature can causes significant changes in the organism's metabolism and other cellular effects. These cellular level effects can adversely affect the mortality and reproduction.

2. **Ecological effects of cold water:** The release of unnaturally cold water from the reservoirs can dramatically change the fish and macro-invertebrate fauna of rivers, and reduce river productivity. For instance, in Australia, many rivers have warmer temperature regimes because of which the native fish fauna have been eliminated and the macro invertebrate fauna drastically altered and impoverished.

Computer modelling of thermal pollution

In 1970, hydrologists, physicists, meteorologists, and computer scientists combined their skills in one of the first inter-displinary pursuits of the modern environmental science era. First came the application of Gaussian function dispersal modelling that forecasts how a thermal plume is formed from a thermal point source and predicts the distribution of aquatic temperature. The ultimate model was developed by the U.S. Environmental Protection Agency introducing the statistical variations in meteorology to predict the resulting plume from a thermal fall.

Heavy metal pollution

All living organisms require certain amount of heavy metals for their growth. Generally, iron, cobalt, copper, manganese, molybdenum and zinc are required to the human beings. Excessive levels of these metals can be detrimental or toxic to the organisms. Other heavy metals such as mercury, Arsenic and lead are toxic metals that have no known vital or beneficial effects to the organisms and their accumulation in the body causes several illness to the organisms. Certain elements such as vanadium, tunguston and even cadmium are normally toxic to the living animals.

Many definition of heavy metals have been proposed. According to the IUPAC technical report, the term heavy metal is meaningless and misleading. There is an alternative term 'toxic metals' for heavy metals. One of the source defined the heavy metals as the common transition metals *viz.*, copper, lead and zinc. These metals cause the environmental pollution from different sources such as petrol, industrial effluents, and leaching of metal ions from the soil into lakes and rivers by the acid rains. Thus, heavy metal is a member of an ill defined subset of elements that exhibits properties which mainly includes transition metals, metalloids, lanthenoides, and actinides.

The heavy metal pollution arises from many sources but the common source is the purification of metals *viz.*, during the smelting of ores and the preparation of nuclear fuels. Electroplating is the primary source of chromium and cadmium. Through, the precipitation of their compounds or by ion-exchange into soil and muds, heavy metal pollutants can be localized and lay in dormant condition. The heavy metals do not decay and thus pose a different kind of challenges for their remediation. A well known documented environmental diaster associated with the heavy metals is the '*Minamata disease*' which was caused by mercury pollution.

The heavy metal poisoning includes the consumption of excessive amount of iron, manganese, aluminium or beryllium or semi-metal like arsenic. Bismuth is excluded due to its low toxicity. Heavy metals are classified as 'miscellaneous' but sometimes they are labelled as 'poison' at the time of transportation.

QUESTIONS

1. What is environmental degradation? How does it effect on our environment?
2. Define pollution and discuss its sources, causes, effects and control measures.
3. What is the difference between the environmental degradation and pollution?
4. Discuss the thermal pollution.
5. Explain heavy metal pollution.
6. Write short notes on:
   A. Environmental degradation
   B. Pollution
   C. Thermal pollution
   D. Heavy metal pollution

14

GREENHOUSE EFFECT AND GLOBAL WARMING

Greenhouse effect is only one of the many effects which influence temperature of the earth. The greenhouse effect was discovered by Joseph Fourier in 1824 and first investigated quantitatively by Svante Arrhenius in 1896. According to him, the greenhouse effect is the process in which the emission of infrared radiations from the atmosphere warms a surface of the planet. The name comes from the incorrect analogy with the warming of air inside a greenhouse than air outside the greenhouse. In the absence of greenhouse effect, the earth's average surface temperature of 14°C would be about -18°C. Global warming, is belived to be the result of an enhanced greenhouse effect due to the increased concentration of greenhouse gases in the atmosphere. Besides earth, mars and venus also have greenhouse effects.

GREENHOUSE EFFECT

The basic mechanism of Greenhouse effect is as follows: The earth receives energy from the sun as radiation. Most of the energy is in visible and in infra-red wavelengths that are near to the visible range. The earth reflects 30% of the incoming solar radiation and remaining 70% is absorbed, warming the land, atmosphere and oceans. The

earth's temperature is to be in steady state, so that the earth does not rapidly heat or cool. With increased intensity of infra-red radiation, the temperature is also increased. The infra-red photons emitted by the surface are mostly absorbed in the atmosphere by the greenhouse gases and clouds do not escape directly into the space. The atmosphere is emitting infra-red radiations both upward and downward. The upward infra-red flux emitted by the surface must balance the downward infra-red flux emitted by the atmosphere. The surface temperature will increase untill it generates thermal radiation which is equivalent to the sum of incoming solar and infra-red radiation.

The greenhouse gases are CO_2, NO_2, SO_2, CH_4, O_3, and chloro fluro carbons etc. These gases are responsible for the global warming, melting of polar ice, climatic changes, crop production and nutrient depletion. CO_2 production from increased industrial activity (fossil fuel burning) and other human activities *viz.*, cement production and tropical deforestation which increase the CO_2 concentration in the atmosphere. In 1960, CO_2 concentration was 313 ppm, which become 375 ppm in 2005. The current amount of CO_2 is ~ 300 ppm in core data. The elevated CO_2 level will increase the global mean temperature. This is only due to the anthropogenic green house gaseous concentration. Certain paleo-climatologists consider variations in CO_2 to be a fundamental factor in controlling climate variations over the time-scale.

The term 'Greenhouse effect' has originally came from the greenhouses used for the gardening, but it is a misnomer because greenhouses operate differently. A greenhouse is a built of glass. It heats up mainly due to the sun warm ground inside it and confined with in the green house. Greenhouses, thus, works primarily by preventing 'convection'. However, the greenhouse effect reduces the radiation loss. Although, the primary mechanism for warming greenhouses is the prevention of mixing hot gases with the free atmosphere.

The radioactive properties of the glazing can still be important to the commercial growers. The modern technology of building greenhouses, has permitted the construction of greenhouses which selectively control the radiation transmittance to better maintain the plant growing environment.

GLOBAL WARMING

Today, the temperature of the earth is increasing rapidly due to the environmental pollution and related problems. This results into the warming of the earth which we commonly called 'global warming'. The increasing global temperature is expected to rise the sea level, an increase in the intensity of extreme weather events and significant changes in the amount and pattern of precipitation are obvious. Other effects of global warming includes changes in agricultural yields, modification of trade routes, glacier retreat, species extinctions and increase in the range of disease vectors.

'Global warming' refers to the warming in the recent decades and its projected continuation, and implies a human influence. The global warming is nothing but the climate change which results into the increase in temperature of the globe. Thus, the global warming is the increase in the average measured temperature of the earth near surface air and oceans. Since the mid 20^{th} century, and its continuation has been projected . The average global air temperature near the earth's surface has increased as 0.74 ± 0.18°C (1.33 ± 0.32 °F) during the century ending in 2005. The Inter-Governmental Panel on Climate Change concluded that most of the observed average temperature started increasing globally from the mid of 20^{th} century. This is mainly due to the increase in anthropogenic (man made) greenhouse gas concentration through the greenhouse effect.

Climate model projections summarised by the Inter-Governmental Panel on Climate Change have indicated that average global surface temperature will likely to rise further from 1.1° to 6.4 °C (2.0 to 11.5 °F) during the 21st century. Most of the studies concluded that global warming and rise in sea level will continue for more than thousand years, even if greenhouse gas levels are stabilized. The delay in reaching equilibrium is a result of the large heat capacity of the oceans. According to some scientists, global warming may vary from region to region around the globe. Most of the national governments prepared a 'Kyoto Protocol' for reducing greenhouse gas emissions but the on going political and public debate is that action should be taken to reduce or reverse future warming or to adapt to its expected consequences.

Causes of global warming

The major causes of global warming are changes in solar luminosity, volcanic eruptions, and atmospheric green house gas concentration. Most of the global warming is mainly caused by the increase in the atmospheric greenhouse gases. It was also hypothesised that warming may be the result of variations in solar activity. The climate commitment studies indicate that even if greenhouse gases were stabilized at 2000 levels, a further warming of about 0.5 °C (0.9 °F) would still occur.

Greenhouse gases in the atmosphere

It is the process by which absorption and emission of infrared radiation by atmospheric gases warms a planet's lower atmosphere and surface.

Naturally occuring greenhouse gases have a mean warming effect of about 33 °C. The major greenhouse gases are water vapours which causes 36% to 70% greenhouse effect. CO_2 causes 9% to 26%, methane (CH_4), 4% to 9%,

and ozone (O_3) 3% to 7%. It was studied that the human activities like industries increase the concentration of various greenhouse gases. Some other natuarally occurring gases also contribute to small fraction of greenhouse effect; one of them is nitrous oxide (NO_2). The present atmospheric concentration of CO_2 is 385 ppm by volume. Further, CO_2 level is expected to rise due to the burning of fossil fuel and land use change. This is only due to the economic, sociological, technological and natural development. Inter-Governmental Panel on Climate Change's special report on emission scenario gave a wide range of future CO_2 concentration ranging from 541 to 970 ppm upto the end of 21st century. The strength of the greenhouse effect depends on the atmospheric temperature, if the rate of temperature decrease, the greenhouse effect will be strong and vice-versa. Another important feedback process is ice-albedo feedback. When the global temperature increases, ice near the poles melt at an increasing rate and when the ice melts, an increase in area of land or open water takes place. Both land and open water on an average are less reflective than ice, and thus, will absorb more solar radiation. This causes more warming, which in turn causes more melting and this cycle continues. A few papers have suggested that sun may have contributed 45% to 50% of the increase in the average global surface temperature.

Temperature changes

The global temperatures on both land and sea have increased by 0.75 °C (1.35 °F) from 1860 to 1900 as per the instrumental record. This temperature increase is not significantly affected by the urban heat island effect. The sea temperature increases more slowly than land. The Northern Hemisphere has more land than the Southern Hemisphere, so it warms faster. The Northern Hemisphere also has extensive areas of seasonal show and sea-ice cover subject to the ice-albedo feedback. As per the NASA's

Goddard Institute for Space Studies, 2005 was the warmest year. Anthropogenic emissions of other pollutants can exert a cooling effect by increasing the reflection of incoming sunlight.

Climate variations

The earth has experienced warming and cooling many times in the past. A rapid buildup of greenhouse gases amplified warming in the early Jurassic period, with average temperature rising by 5°C. A research showed that the warming caused the increase in rate of rock weathering by 400%.

Scientists have reported the global warming with computer model of the climate. These models are based on the physical principles of fluid dynamics, radioactive transfer and other processes. These models predict that the effect of adding greenhouse gases is to produce a warmer climate. In May, 2008, on the basis of observations on the inclusion of oceanic temperature, it was predicted that the global surface temperature may not increase over the next decade, as natural climate variations in the North Atlantic and Tropical Pacific temporarily offset the projected anthropogenic warming. The models do not accurately predict changes in the temperature profile in the tropical troposphere.

Effects of global warming

It is difficult to say about weather events to the global warming but an increase in the global temperature may cause broader changes including glacial retreat, Arctic shrinkage and increase in the sea level world-wide. Changes in the precipitation may results in flooding and drought. There may also be changes in the frequency and intensity of extreme weather events. Other effects include changes in the agricultural yields, addition of new trade

pattern, reduced summer stream flows, species erradication, and increase in the vectors of diseases.

Increasing death rates, displacements and economic losses may also be due to global warming. This is expected to increase the potential geographic range and virulence of tropical diseases. Climate change may cause insect born diseases *viz.*, malaria throughout Europe, North America and North Asia. Developing countries, primarily depending upon agriculture will be particularly harmed by the global warming. The increased publicity of the scientific findings about global warming may also results into political and economic debate.

Related climatic issues

A variety of issues are raised in relation to the global warming. One of them is acidification of oceans. Increased atmospheric CO_2 increases the amount of CO_2 dissolved in the oceans and it reacts with water to form carbonic acid resulting into acidification. Oceanic surface pH decreased from 8.25 to 8.14 in 2004. Ozone depletion is frequently cited in relation to the global warming.

QUESTIONS

1. What do you understand from greenhouse effect and global warming?
2. What are the greenhouse gases?
3. Write a short note on:
   A. Greenhouse effect
   B. Global warming

15

RADIATION ECOLOGY

Radiation is the emission of the rays and particles from a source. The source of solar radiations is sun. In other words, radiation is the energy in the form of waves or sub-atomic particles emitted by an atom or other body which changes its state from higher to lower state. The word 'radiation' is mostly used for ionizing radiations which is a group of radioactive elements. The ionizing radiation has enough energy to ionize the atoms or molecules. The radiation ecology is an important branch of environmental biology which deals with the study of gross effects of radiations and radioactive substances on the environment and living organisms. The unit of radiation is 'rad'.

The radioactive substances are uranium, radium, X-rays etc. The X-rays were discovered by Rontgen and radium by Marrie and Pierre Curie in 1898. According to Marrie Curie this new element was 2 million times more radioactive than uranium.

TYPES OF RADIATIONS

Basically, there are two major types of radiations: *viz.*, ionizing, and non-ionizing radiations.

Ionizing radiations

The ionizing radiations consists of highly energetic particles or waves that can ionize atleast one electron from an atom or

molecule. Its ionizing ability depends on the energy of individual particles or waves and not on their numbers. There are 3 principle types of ionizing radiations *viz.*, α, β and γ. All these radiations are emitted from the nucleus of an unstable atom. The ionizing radiation has both useful and harmful aspects. It is used in medicine, research, construction and other areas, but causes health hazards, if used improperly. If these radiations occur in biological system, they may be destructive and cause the damage of DNA. The extensive dose of these radiations causes mutations in the victims.

The α, β, γ and other ionizing radiations are produced by the radioactive decay, nuclear fission and nuclear fusion and by particle accelerators. For the ionization of a particle, it must have high energy and interacting capacity with the atom of target. Photons (light) interact strongly with charged particles. So they may be ionizing. Charged particles are electrons, positrons and particles.

Ionizing radiations are dangerous in direct exposure. It effects both human beings and animals. If radioactive isotopes are present in the environment, they may be taken into the body *e.g.*, radioactive iodine is treated as normal iodine by the body and used by the thyroid. Its accumulation often leads to the thyroid cancer. Some radioactive elements are also bioaccumulated.

Uses of ionizing radiations:

The uses of ionizing radiations are enumerated here.

1. In biology, radiation is mainly used for sterilization, and enhancing mutations *e.g.*, mutations may be introduced by radiations to produce new or improved species. A very promising field is the sterile insect producing technique, where male insects are sterilized and liberated in the chosen field. So that, they are not be able to mate and have no descendants and the population is reduced.

2. Ionizing radiations are useful in sterilizing medical hardware or food. The advantage for the medical hardware is that the object may be sealed in plastic before sterilization. For food, there are strict regulations to prevent the occurrence of induced radioactivity.
3. The growth of seedling may be enhanced by the radiation but excessive radiation stops the growth of seedling.
4. Electrons, X-rays, γ-rays or atomic ions may be used in radiation therapy to treat malignant tumours (cancers).

Natural background of radiation: It comes from four primary sources. These are: cosmic radiation, solar radiation, extra-terrestrial sources, and radon.

The most common human made radiations are X-rays which are deposited in people's body who get CAT scans. Some human made radiation sources affect the body through direct radiation and others take form of the radioactive contamination and irradiate the body from within. In medical, X-rays, nuclear medicine, radiation therapy are the most significant sources of human made radiation exposure to the general public. Radionuclides used are I^{131}, Tc^{99}, Co^{60}, Ir^{192} and Cs^{137} which rarely released into the environment. The public is also exposed to the radiations from the consumer products *viz.*, tobacco (Polonium-210), building materials, combustible fuels (gas, coal etc.), ophthalmic glass, luminous watches and dials, X-ray systems, smoke detectors, road construction materials, electron tubes, fluroscent lamp starters, and lantern mantles (thorium) etc.

Biological effects of ionizing radiations: The biological effects of radiation are the effects on living cells. The body repairs many types of radiation caused changes and chemical damage.

Biological effects of radiation on living cells may results in a variety of outcomes including:

1. Cells experience DNA damage but are able to detect and repair the damage.
2. Cells experience DNA damage and are unable to repair the damage. These cells may go through the process of programmed cell death and thus eliminate the potential genetic damage from the large tissue.
3. Cells experience a non-lethal DNA mutation. These mutations may cause cancer.
4. Other observations at the tissue level are more complicated such as a small radiation dose will reduce the impact of a subsequent and large radiation dose.

Control of ionizing radiations: Radiations always present in the environment and in our bodies. The human body can not sense ionizing radiation but a range of instruments exist which are capable for detecting at even very low level of radiation from the natural and man made sources. The control measures are as follows:

1. Geiger counters and scintillation counters measure the dose and rate of ionizing radiation directly.
2. There are four standard ways to limit exposure are time, distance, shielding and containment.
3. In nuclear war, an effective fallout shelter reduces the human exposure at least 1,000 times. Most people can accept doses as high as 1 Gy distributed over several months.
4. Potassium iodide tablets effectively block the uptake of dangerous radioactive iodine into the human thyroid gland.

Non-ionizing radiations

These radiations refers to any type of electromagnetic radiations that do not carry enough energy per quantum to ionize atoms or molecules. Near ultra-violet, visible light, infra-red, micro-wave, radio-waves, low frequency RF and static field are the examples of non-ionizing radiations. The effects of non-ionizing radiations are as follows:

1. Ultraviolet light causes burn to the skin and cataract to the eyes.
2. Ultraviolet light produces free radicals that introduce cellular damage which can be carcinogenic.
3. Plastic sun glasses (polycarbonate) generally absorb ultraviolet radiations but its over exposure to eyes may cause snow blindness particularly on the sea and snow ground.
4. Bright visible light irritates the eyes.
5. Very strong visible light is used for cauterizing hair follicles.
6. The micro-wave and radio-frequency radiations cause biological effects *viz.*, effects on the skin, eyes, and other organs. Similar effects are caused by the low frequency ELF and static fields.

Problems caused by the radiations

1. Environment with high level of ionizing radiation create special design challenges. A single charged particle can knock the thousand of electrons to loose, causing electronic noise and single spikes. This is a serious problem particularly in the design of artificial satellites, spacecrafts, military aircrafts, nuclear stations and nuclear weapons.
2. Nuclear reactors produce gamma radiation and neutron radiation which can affect sensor and control circuits in the nuclear power plants.

3. In nuclear war, nuclear explosions concern all civilian and military services.
4. Cosmic rays effect the stratospheric jets and satellites.
5. Solar particles directly coming from the sun cause problems to the satellites ranging from radiation damage to the loss of altitude by heating up the upper region of the atmosphere.
6. The radioactive materials may cause radiation poisoning.

RADIOACTIVE DECAY

This is the process in which an unstable atomic nucleus loses energy by emitting radiation as particles or electronic waves. This decay or loss of energy, results in an atom of one type called 'parent nucleotide' transforming to an atom of a different type called the 'daughter nuclide' *e.g.*, a carbon-14 atom (the 'parent') emits radiations and transform to a nitrogen- 14 atom (the 'daughter'). This is a random process on the atomic level, the decay rate, on average, is predictable. The unit of radioactive decay is Becquerel (Bq). 1 Bq is one transformation per second.

Modes of radioactive decay

I. **Decays with emissions of nucleons:** These are alpha decay, proton decay, neutron decay, cluster decay, spontaneous fissions, and double proton emission.

II. **Different modes of beta decay:** These are β-negative decay, electron capture, double β-decay and double position emission.

III. **Transition between states of the same nucleus:** These are gamma decay, and internal conversion.

The decay rate or activity of a radioactive substance characterized by the constant quantities and time variable quantities.

1. **Constant quantities:** These are of three types *viz.*, half life, mean life time, and decay constant.
   A. **Half life:** Half life is the time taken for the activity of a given amount of a radioactive substance to decay to half of its initial value.
   B. **Mean time:** This time is the average life time of a radioactive particle.
   C. **Decay constant:** This constant is the influence of the mean life time.
2. **Time-variable quantities:** These are also of three types: Total activity, number of particles, and specific activity.
   A. **Total activity:** This activity is the number of decays an object undergoes per second.
   B. **Number of particles:** It is the total number of particles in the symbol.
   C. **Specific activity:** This activity is the number of decays per second per amount of the substance.

RADIOACTIVE CONTAMINATION

The radioactive contamination is an uncontrolled distribution of the radioactive material in a given environment. The radioactive contamination is typically the result of a spill or accident during the production or use of radio nuclides (radio isotopes). An unstable nucleus which has excessive energy. Contamination may occur from the radioactive gases, liquids or particles *e.g.*, if a radio nuclide used in a nuclear medicine is accidently spilled, the material could be spread by the people as they walk around. Radioactive contamination may also be an

inevitable result of certain processes *e.g.*, the release of radioactive xenon in nuclear fuel reprocessing.

This contamination may exist on the surface or in volume of the material or air. In a nuclear power plant, detection and measurement of radioactivity and contamination is often the job of a certified health physicist.The radioactive contamination takes place into the body through ingestion, inhalation, absorption or injection. For this reason, it is important to use personal protective equipments while working with the radioactive materials. The radioactive contamination may also be ingested as the result of eating contaminated plants and animals or by drinking contaminated water or milk from the exposed animals.

The biological effects of radioactive contamination include radiation poisoning. These effects mainly depend on the activity and biodistribution and removal rates of the radio nuclides which in turn depends on its chemical form *e.g.*, the thyroid gland takes up a large percentage of radioactive iodine that enters into the body. If the large quantity of iodine is inhaled or ingested, the thyroid may be impaired or destroyed as well as other tissues will be affected to the lesser extent. Similarly, the radioactive iodine is used in the diagnosis and treatment of many diseases of thyroid precisely due to the thyroid's selective uptake of iodine.

QUESTIONS

1. What do you understand from radiation ecology?
2. Define radiation and discuss on its types.
3. State the problems caused by the radiation.
4. Differentiate between ionizing and non-ionizing radiations.
5. Write short notes on:
   A. Radioactive decay
   B. Radioactive contamination, and
   C. Ionizing radiations

16

URBANIZATION

Today's life style is changing rapidly due to the development as a result of educational and financial upliftment. The people require more money for improvement because of their socio-economic standards. Many rural people are coming to the city for fulfilling their needs and settle down in the city. Thus, the population of cities increases slowly and rural areas become less populated. Now a days, the urbanization is a big problem for the government especially its maintenance. The cities are going to be extended towards villages by occupying more and more space. Naturally, it affects the balance of the ecosystem. This is caused only due to the industriliazation and urbanization. The urbanization can be defined as the physical growth of urban areas into the rural area or natural land. The effects of urbanization include changes in the population density and administrative services. The urbanization is mainly due to the movement of people from rural to urban areas with population growth equating to urban migration.

CAUSES OF URBANIZATION

Urbanization is considered to be the movement of people from rural to urban areas sharing the resources meant for urban population. Acoording the report of World Urbanization, the global population of urban areas has rose dramatically from

13% (220 million) in 1900 to 29% (732 million) in 1950 to 49% (3.2 billion) in 2005 and the figure will rise to 60% (4.9 billion) by 2030. Thus, the urbanization is increasing steadily. The United States of America and United Kingdom have a far high level of urbanization than the other countries like China, India etc. According to the Annual Report of United Nations Habitat-2008, the majority of the people in the world will be living in town and cities. Considering the future, 93% of the urban growth will occur in Asia and Africa and by 2050. 6 billion people will be living in towns and cities.

The urbanization occurs naturally by the individuals and corporate sector for job, education, housing and transportation. Living in cities permits individuals and families to take advantages of opportunities of proximity, diversity and market competition. Most of the people come to cities for employment and financial purposes. The future of rural people is subjected to unpredictable environmental problems *viz.*, drought, flood, food problem etc. because of which their survival becomes more problematic.

The cities are well known places where money and wealth is centralized. Business generates jobs and capital in the city. It is also a source of trade and tourism. Thus, the urbanization and industrialization create new jobs and then farms become more mechanized putting many labours out of work.

EFFECTS OF URBANIZATION

The effects of urbanization are to be studied under following two heads: economic effects and environmental effects.

Economic effects

In the last few years, the urbanization of the rural areas has increased due to the agriculture and small scale industries which give a way to the modern society. Research

in the urban ecology shows that larger cities provide more specialized goods and services to the local markets and surrounding areas, function as trans portation and wholesale hub for small places, accumulates more capital, financial services and educated and skilled labour force.

As the cities grow, it results into the urbanization which affects the environment, population and financial budget of the city. It dramatically increases the cost of living and other expenses. Living in cities permits individuals and families to take advantages of the opportunities of urbanization (proximity, diversity, market etc.).

Environmental effects

Because of urbanization, the heat of urban areas increases by 1° to 6°C than the surrounding landscapes. There is also reduction in the moisture of soil and intensification of carbon dioxide (CO_2) emissions. Due to the urbanization, the environment is becoming polluted. In future, there may be shortage of water and food. Thus, the urbanization is effecting the environment severally.

CHANGES IN THE URBANIZATION

According to the traditional urbanization, the human activites and settlements take place in the down town but now the residential areas are shifting outward and is referred as 'sub-urbanization'. This is also known variously as edge city, network city, post modern city etc. Los Angeles is the best known example of such type of urbanization.

QUESTIONS

1. Define urbanization. How urbanization effects the environment?
2. What are the causes of urbanization?
3. Write a short note on:
   A. Urbanization and changing form of urbanization.
   B. Effects of urbanization

17

BIODIVERSITY

The earth is a home to a rich and diverse array of living organisms, whose genetic diversity and relationship with one another and the physical environment constitute biodiversity. Biodiversity is the natural biological capital of the earth that presents important opportunities for all nations. It provides goods and services essential to support human livelihoods and aspirations. It also enables societies to adapt the changing needs and circumstances. The protection of these assets and their continued exploration through science and technology, offers the only means by which the nations of the world can hope to develop sustainably. The ethical, aesthetic, spiritual, cultural and religious values of human societies are an integral part of this complex equation.

Biodiversity or biological diversity is a more comprehensive term, meaning the diversity or variety of all living organisms. The biodiversity is the characteristics of all living beings to be formed by many and different entities. It is a basic property of life and it manifests itself at all levels from cell to ecosystems. It includes all varieties of plants, animals and micro-organisms. The term biodiversity is applied to the species diversity, habitat diversity and genetic diversity that includes composition, structure and function of the living beings. The composition

of biodiversity emphasizes the variety of species, structure in the physical organization and functions *viz.*, energy flow, nutrient cycling and disturbances. The biodiversity can be defined as, the total variety of living organisms including plants, animals and micro-organisms on the earth. We can measure the diversity of plants and animals but biodiversity is still more complex. Biodiversity encompasses all forms of life at all levels, from the genetic DNA to soil micro-organisms to large vertebrates to large communities of deserts, forests and oceans.

India is recognized as a country uniquely rich in all aspects of biodiversity including ecosystem, species and genetic. It has perhaps the largest array of environmental conditions by virtue of its tropical location, varied physical features and climatic types. India has the widest variety of biomes, an attribute further enhanced by the meeting of 3 major biogeographic realms *viz.*, Indo-Malayan (the richest in the world), the Eurasian and the Afro-tropical. India owes its unique biodiversity to this unmatched interspersion of biogeographic and environmental values. It is estimated that over 45,000 species of flora and 75,000 of fauna are found in India. Over the centuries, people in India have a fascination and respect for this natural heritage. These sentiments were expressed in the *'Upanishad'* which dates back to over 2000 years.

DISTRIBUTION OF BIODIVERSITY

The distribution and magnitude of the biodiversity that exists today is a product of over several billion years of evolution, involving species migration, extinction and more recently human influence. Recent estimates of the total number of species ranges from 7 to 20 million, but we believe that a good working estimate is between 12 and 14 millions. Of which only about 1.75 million species have been scientifically described. Less studied groups of

organisms include bacteria, arthropods, fungi and nematodes, while species that live in marine environment and beneath the ground are especially very poorly known. Even for the 1.75 million species described, there is no comprehensive listing and have incomplete and patchy understanding of their reproductive biology, demography, the chemicals which they contain, ecological requirements and the roles they play in the ecosystem.

Diversity of species and genes affect the ability of ecological communities to resist or recover from disturbance and environmental changes, including long-term climatic changes. Genetic variations within the species are the ultimate base of evolution. The adaptation of wild populations to local environmental conditions and development of animal breeds and cultivated crop varieties which have yielded significant direct benefits to humanity. Loosing the diversity of genes within the species, species within ecosystems and ecosystems within a region make it even more likely that further environmental disturbance will result in serious reduction in the goods and services that the earth's ecosystems can provide.

IMPORTANCE OF BIODIVERSITY

All the forms of living material are important to our biosphere and natural system. In a complex system, the loss of one species may not disrupt the entire system. Thus, the notation that the more diverse systems are more stable is quite valid. Scientists have estimated that more than 1,000 species on the earth are becoming extinct every year. This rate is likely to reach 5, 000 per year by 2010. Extinction is, thus, a major problem because we loose genetic diversity, important links in a species and community by the way of this process. In this way, we loose important sustainable economic development and the quality of life. The loss of

biological resources and their diversity threaten our food supply, sources of wood, medicines and energy, opportunities for recreation and tourism and interfere with essential ecological functions *viz.*, the regulation of water run off, the control of soil erosion, the assimilation of wastes, purification of water, and the cycling of carbon and nutrients. The major causes of reduction of biodiversity are: 1. Natural causes of extinction, 2. Human caused reduction in biodiversity, and 3. Predator and pest caused reduction.

During the last few millennia, species have been extinct as a result of human activities. The worldwide loss or conservation of habitats that has already been taken place and more than 10,000 species have been committed to extinction. It is not possible to take preventive action to save all of them. For some groups of vertebrates and plants, between 5 and 20% of the identified species are already listed as being threatened with extinction in the foreseeable future. These estimates depend strongly on predictions of future rates of forest loss which may increase or decrease. They will also be modified by the efforts of conservation action *viz.*, the protection of areas of high diversity. The primary causes underlying the loss of biodiversity are demographic, economic, institutional and technological factors. These are as follows:

1. Increasing demands for biological resources due to increasing population and economic development.
2. Failure of people to consider the long-term consequences of their actions, often due to a basic lack of heritage.
3. Failure of people to appreciate the consequences of using inappropriate technology.
4. Failure of economic markets to recognize the true value of biodiversity.
5. Institutional failures to regulate the use of biological and ecological based management systems, which

take away resources resulting from the growth in urbanization, changes in the property rights and shifting cultural attitudes.

6. Failure of government policies to address the over use of biological resources, and
7. Increasing human migration, travel and international trade.

These underlying causes manifest themselves in the loss, fragmentation and degradation of habitats. The conversion of natural habitats to other uses, over exploitation of wild resources, introduction of non-native species, pollution of soil, water and atmosphere and more recently signs of long-term climate changes are some factors affecting the biodiversity.

BIODIVERSITY CONSERVATION

Methods of biodiversity conservation are as follows:

1. **Biodiversity management:** The conservation and sustainable use of biodiversity needs to become an integral component of economic development by correcting policies and market failures. This will require much greater level of co-oporation and co-ordination for the management of natural resources. A balanced mix of incentive and disincentives, working along the side of conservation laws, market adjustments and traditional regulatory techniques are needed in managing biodiversity at the national level. Institutional and legal frame work are needed to ensure that conservation and sustainable use of natural resources are integrated successfully into the wide range of social, cultural and economic contexts in which actions must be taken. The adaptation of accountability the effects on biodiversity of extracting goods and using ecological services, promises a way of balancing human socio-economic and long term ecological considerations.

2. **Conservation of biodiversity:** A wide variety of measures can be used to conserve biodiversity, including both *in-situ* and *ex-situ* methods. *In-situ* approaches include legal protection of endangered species, the preparation and implementation of species management or recovery plans and establishment of protected areas to conserve individual species and habitats. Protected areas generally must be augmented by additional measures *viz.*, presentation or establishment of safe corridors through areas of intensive human use and must also return some economic benefit to local human populations. Presently, the different biomes are covered by protected areas.

   Ex-situ conservation centres such as arboreta, aquaria, botanical gardens, seed banks, clonal collections, microbial culture collections, field gene banks, forest nurseries, propagation units, tissue and cell cultures unit, zoological gardens and museum can help to conserve stocks of both wild and domesticated animals, plants and micro-organisms but are also able to maintain their populations. Restoration and rehabilation of habitats, which depend on the availability of materials and its multiplication. *Ex-situ* conservation will come to play increasingly important roles in re-establishing degraded and damaged ecosystems.
3. **Sustainable use of biodiversity:** It is a key component of sustainable social and economic training. Training must be provided for those involved in managing protected areas, preparing biodiversity inventories and developing and safe guarding *ex-situ* collections of all kinds. Essential training aspects are useful in development of management plans. Management systems must take this into account explicitly, recognizing that social and economic

measures may be just as important as technical considerations. Flexibility of management is also needed, so as to be able to respond to the changing social, biological and physical environments while still maintaining essential ecosystem functions. Appropriate incentives and the enforcement of management decisions and policies must be ensured. Finding the appropriate balance depends on the particular cultural, legal, economic, ownership, tenure and biological circumstances in each individual country.

4. **Equitable sharing benefits:** An equitable sharing of income and assets is an important component of a strategy for conservation of biodiversity should be emphasized. Biodiversity conservation is a prerequisite for creating the incentives needed to maintain the earth's biological wealth. Local benefits showing the effect of lowering the opportunity and cost of forgoing conservation to commercial or other uses *viz.*, arable agriculture, pasture or industry must be equally shared.
5. **Research activities:** Enhanced research, inventorying and monitoring of biodiversity are important to promote responsible policy making and management. Research in the application of biodiversity and further research into the provision of ecological services are essential. These services can be sustained indefinitely. Monitoring and inventorying are needed so that newly discovered life forms can be properly documented.
6. **Building national capacity and expertise:** Committed and skilled people are the key of successful maintenance and sustainable use of biodiversity. Training must be provided to those involved in managing protected areas, conducting biodiversity inventories and developing and safe guarding *ex-situ* collections of all kinds. Essential training aspects are useful in management of forestry, fishery and

agriculture. National training programmes and international exchange programmes must concentrate on producing more skilled scientists, particularly in the developing countries. Educating the public and making people aware of the issues involved in biodiversity are essential elements in improving the decision making process.

Famous conservation biologist, R. E. Grumbine (1989) has suggested four management principles for protecting biodiversity on large-scale and long-range approach. These principles are:

1. Protect enough habitat for viable populations of all native species in a given region.
2. Manage natural disturbances *viz.*, fire, wind, climate changes etc.
3. Plan over a period of centuries so that species and ecosystem may continue to evolve.
4. Allow the human uses that do not result in significant ecological degradation.

International biodiversity conservation strategy

In 1975, Convention on International Trade of Endangered Species (CITES) had taken a significant step towards world-wide protection of endangered flora and fauna. In 1997, 'CITES' meeting was held at Zimbabwe and a proposal was made to regulate international trade in a potentially invasive alien (non-indigenous) species. Other agencies involved in the conservation of biodiversity are:

1. World Conservation Strategy (1980): UNEP, IUCN and WWF sponsored programme.
2. World Conservation Monitoring Centre: UNEP supported organization.
3. International Board for Plant Genetic Resources.

4. Microbial Gene Banks and Training Centres: UNESCO collaborated centres.
5. Convention of International Trade of Endangered Wild Fauna and Flora (CITES): A UNEP supported programme.
6. Conservation of Migratory Wild Animals: A UNEP supported programme.

Present status of biodiversity in India

India has a rich and varied heritage of biodiversity figuring with two hotspot areas *viz.*, Western ghats and Eastern Himalayas. These areas had 18 biodiversity hotspots found out during 1980. Now their number has increased upto 30. India has 26 recognized endemic centres and contributes significantly to the latitudinal biodiversity trend. India accounts for 7.31% of the global faunal species (Total count is nearly 86,451 species). Indian record in agro-biodiversity is equally impressive. There are 167 crop species and wild relatives. India is considered to be the centre of origin of 30,000 to 50,000 varieties of rice, mango, turmeric, ginger, sugarcane etc. and ranks seventh in contribution to the world agriculture.

ENDANGERED SPECIES

As many as 500 million kinds of plants, animals and micro-organisms have made this planet as their home since life began over 3.5 million years ago. Today, only 5 to 10 million species are alive. We do not know exactly how many species are there because there are many biologically uncharted areas such as the tropical rain forests where some estimate over 90% of the living organisms remain unclassified. Thus, since has life began, about 490 million species have become extinct. An account of endangered species of amphibia, reptiles, birds and mammals as well as invertebrates is as follows:

Endangered vertebrate fauna of India

1. **Endangered species of Amphibia:** The endangered species of amphibia are the viviparous toad and Indian salamander.
2. **Endangered species of Reptiles:** The endangered species of reptiles are several turtles (including trunk turtle, green sea turtle and olive turtle), crocodiles (Estuarine crocodile, marsh crocodile and gharial), lizards (Indian monitor lizard, desert monitor lizard, water monitor lizard and clouded monitor lizard) and snakes (Indian or rock python and reticulated python).
3. **Endangered species of Aves:** There are about 2100 species and sub-species of birds known in India, of which a large number of birds are greatly endangered. Important are some species of (i) Ducks and swans, (ii) Hawks and eagles, (iii) Game birds like Phasianid birds, (iv) Pheasant, (v) Cranes, (vi) Bustards and (vii) Hornbills.
4. **Endangered species of Mammals:** About 350 species constitute the mammalians fauna in India, of which 87 species of mammals are greatly endangered. Most of the endangered species of mammals are Pangolin, musk deer, spotted deer, Kashmir stag, Indian gazelle, rhinoceros, elephant, lion, tiger, wild buffalo, Indian bison, lion tailed monkey and giant squirrel etc.

Endangered invertebrate fauna of India

1. **Crustacea:** The coconut or robber crab (a large hermit crab).
2. **Insecta:** Some dragonflies, butterflies, moths and beetles are endangered, but most endangered ones in tillyard dragonfly. Of moths and butterflies about 55 forms are known in India, of which 14 are rare.

These are some more animal species which have been identified as endangered one. This may not be the complete list and many more may be added into the list.

PROTECTED AREAS NETWORK

Due to the continuous increase in the number of endangered species of flora and fauna, steps have been taken to protect and manage the wildlife of country. The Non-Governmental Organisations as well as Governmental organisations at state and central levels have been set up to protect the wildlife. *In-situ* conservation of wildlife includes a comprehensive network of protected areas. There are different categories of protected areas which are managed with different objectives for providing benefits to the society. These include: (i) National Parks, (ii) Sanctuaries, (iii) Biosphere reserves, (iv) Nature Reserves, (v) Natural monuments and (vi) Cultural landscapes etc. These areas may differ considerably in size, design, purpose and effectiveness of management but together form a solid basis of conservation of biological diversity. At the 15th meeting of Indian Board of Wildlife, held on 1 October 1982, Late Mrs. Indira Gandhi, Prime Minister of India, proposed a 12 point action plan for the conservation of wildlife in India. This included the establishment of a network of scientifically managed protected areas including national parks, sanctuaries, biosphere reserves and other areas. It has been suggested that there should be148 national parks and 503 sancturies to cover an area of 1,51,000 sq.km (about 4.6%) of country's geographic area.

Conservation projects on endangered species: The Government of India has started some special conservation projects to protect the selected wildlife. These are project tiger, Gir lion project, elephant project, crocodile breeding project, snow leopard project etc. Some important projects are described here.

1. Tiger Project

There were about 40,000 Royal Bengal tigers in 1909-10. All India Tiger Census conducted in 1972, revealed that there were only 1827 tigers *(Panthera tigris)* in the country as compared to 40,000 tigers in the country. At present total number of tigers is estimated to only. Taking this as an indication of the deteriorating health of India's wildlife, the Government of India launched 'Project Tiger' in 1973 with the support of WWF-International. At the time launching the project, the Prime Minister of India, Mrs. Indira Gandhi said that "The tigers cannot be preserved in an isolation. It is at the apex of a large and complex biotope. Its habitat threatened by human intrusion, commercial forestry and cattle grazing must first be made inviolate."

Today, there are 18 tiger reserves comprising an area of 28,017sq. km of which the core segment is 12,634 sq.km. Fire protection and habitat development activities have increased the vegetation and improved the water regions of the reserves. A core zone of minimum 300 sq. km has been identified in each reserve alongwith a suitable area of buffer zone. Forestry operations and cattle grazing have been completely banned in the core zones and these are being reoriented and recognized.

During 1989, the tiger population had more than doubled and was estimated as 4200. The tiger had not been only beneficiary, a number of other endangered species *viz.*, swamp deer, elephant, rhino and wild buffaloes have received protection. The floral diversity of the tiger reserve has also shown a significant improvement. This programme has thus had a direct impact on conservation of biodiversity. The enhanced programmes induced in the 2nd phase of project tiger are establishment of guidelines for tourism in the tiger reserves, management of buffer areas, integration of local population through eco-development programmes and establishment of nature interpretation centres.

2. Gir Lion project

The Gir forest in the Saurashtra region of Gujarat is unique and is only surviving habitat of the Asian lions, *Panthera leo persica*. At present in the whole of Asia, this lion is found only in Gir forest of Gujarat. Clearing of forest for agriculture, excessive cattle grazing and other factors led to decline in the lion population. A 5 year Plan was prepared in 1972 by the Government of Gujarat for this project. Total area of Gir Sanctuary is now 1412 sq km. The central core zone of about 140.40 sq km was constituted as a National park in 1975 and now it has increased upto 258.71 km. Ultimately, the entire sanctuary was declared as National Park. As a result of this, there has been increase in the lion population.

3. Elephant Project

This project was launched in 1992 with the aim at ensuring long-term surrival of elephant population which is presently under serious threat. In the project plan, restoration of the lost and degraded habitats of the elephants including the creation of corridors for their migration and establishment of data base on the migration as well as the collection of data on the population dynamics of elephants have been emphasized. It also aims at improving the quality of life of people living around elephant habitats through sustainable development.

4. Crocodile Project

The Government of India had started the Crocodile Breeding and Management Project in 1976 with the assistance of FAO/UNDP to save all 3 endangered species of crocodiles *viz.*, the freshwater crocodile *(Crocodylus palustris)*, saltwater crocodile and the rare gharial *(Gavialis gangeticus)*. The project surveyed the remaining crocodile habitats and facilitated their protection through

declaration of sanctuaries and national parks. Captive breeding and re-introduction programmes cover regimented collection of eggs from the wild, hatching and rearing in captivity. Research and training is necessary for all these activities. Till 1980, 11 sanctuaries had been declared especially for crocodile protection including the tri-state, National Chambal Sanctuary in Madhya Pradesh. By then, thousands crocodiles of all three species had been reared at 16 centers, several thousand of these had been released in the wild regions. This Project has, thus, secured conservation of crocodilians on a long-term basis.

5. Rhino Conservation Project

In 1987, the centrally sponsored scheme on conservation of Rhinos in Assam was introduced in Kaziranga National Park and it is continued for the effective and intensive management of rhino habitats.

6. Snow Leopard Project

This Project is being taken to create 12 snow-leopard reserves throughout the Himalayas.

BIOSPHERE RESERVES

Biosphere reserve network programme was launched by UNESCO in 1971 under the Man and Biosphere (MAB) programme. The aims of the biosphere reserve programme are:

(i) To conserve the representative samples of the ecosystems.

(ii) To provide long-term *in-situ* conservation of genetic diversity.

(iii) To promote and faciliate basic and applied research and monitoring.

(iv) To provide opportunities for education and training.

(v) To promote appropriate sustainable management of the living resources.

(vi) To promote sustainable development.

(vii) To promote the international co-operation.

The special features of this programme are conservation, research, education and local involvement. Biosphere reserves include the natural, minimally disturbed, man-modified and degraded ecosystems. For the management purposes, the biosphere reserves are divided into five zones *viz.*, (i) Core zone which represents the natural and minimally disturbed ecosystems, (ii) Manipulation (forestry) zone, which includes the man made forests and selected felling area, (iii) Manipulation (Tourism) zone, includes areas marked for tourism, education and training, (iv) Manipulation (agriculture) zone in which tribal settlements and other cultivated lands are included, and (v) Restoration zone includes degraded areas selected for restoration to natural or near to natural conditions.

The Indian region is fairly rich in biological diversity. About 45,000 species of plants and 95,000 species of animals are noted by the taxonomists. The Indian Man And Biosphere Committee (1979) had identified a network of representative ecosystems to protect the biosphere reserves. These are given in Table 17.1.

Eco-development programmes in the areas surrounding the biosphere reserves, participation of local people in the management, research, monitoring, training and education through organizing Paryavaran Kendras (Environmental Centres) are the key features of the MAB programme. In India, the first biosphere reserve came into existence during 1986, was Nilgiri biosphere reserve, covering an area of 5,520 km. The second reserve is the Nandadevi biosphere reserve, it covers an area of 1560 sq km. It was established in 18th January 1988. In this way,

Table 17.1. Biosphere reserves in India.

Biosphere reserves	States/Union Territory
Namdapha	Arunachal Pradesh
Uttarakhand	Uttarakhand
Gulf of Mannar	Tamilnadu
Sunderbans	West Bengal
Thar desert	Rajasthan
Manas	Assam
Little Rann of Kutch	Gujarat
Islands of Andamans	Andaman and Nicobar
Nanda Devi	Uttarakhand
Kaziranga	Assam
Madhya Pradesh	Kanha Kesari
Nokrek (Tura Range)	Meghalaya
Nilgiris	Karnataka, Kerala and Tamilnadu.

13 biosphere reserves have come into existence, one after the other. Thus, biosphere reserve programme is an excellent method for the implementation of world conservation strategy. Today, in the world, there are 226 biosphere reserves in the 62 countries covering an area over 115 million ha.

QUESTIONS

1. Give an account of biodiversity of India.
2. What are the major causes of loss of biodiversity?
3. Explain the methods of biodiversity conservation.
4. What is the biosphere reserve programme? Discuss its objectives and position in India.
5. Write notes on following:
   A. Endangered species of India
   B. National parks and sanctuaries
   C. Project tiger
   D. Biosphere reserve programme
   E. Biodiversity
   F. Causes and loss of biodiversity
   G. Conservation of biodiversity

18

ENVIRONMENTAL POLLUTION

Today India is among the first ten industrialized countries of the world. We have a good industrial infrastructure in core industries like metal, chemical, fertilizer, petroleum, food processing etc. What has come out of these industries? Pesticides, detergents, plastics, solvents, fuels, paints, dyes, food additives etc. are some of the examples of substances which influence the environment adversely and have caused pollution. Due to progress in atomic energy, there has also been an increase in radioactivity in the biosphere. There are large amount of industrial effluents and emissions particularly poisonous gases in the atmosphere. Mining activities have also added to this problem, particularly the solid waste. Thus, pollution is a gift of industrial civilization and has become a major environmental problem today. It is one of the greatest threat posed not only to the humanity but to the whole biosphere.

Pollution can be defined as "any undersirable change in the physical, chemical or biological characteristics of air, water and soil that may harmfully affect the life or create a potential health hazard of any living organism. Pollution is caused due to pollutants. What are pollutants? Any substance that causes pollution is called as pollutant. A pollutant may thus include any chemical or geochemical

(dust, sediment etc.) substance, biotic component or its products or physical factors like heat. Pollutants may be solid, liquid or gaseous substances and are the residues of things we make, use and throw away. There are many sources of such pollutants. Lakes and rivers are polluted by wastes from chemical and other factories and the air by gases of automobile exhausts, industries, thermal power plants etc. The pollutant may also be non-biodegradable and biodegradable. The biodegradable pollutants like sewage can be degraded by biological means but non-biodegradable pollutants like heavy metals and pesticides can not be degraded biologically. There are many pollutants which pollute the air, water and soil. They are as under:

1. **Deposited matter:** Soot, smoke, tar, dust, grit etc.
2. **Gases:** Automobile exhaust and industrial gases like oxides of nitrogen, sulphur, carbon monoxide, halogens etc.
3. **Acid droplets:** Sulphuric acid, nitric acid etc.
4. **Fluorides:** Fluorides
5. **Agro-chemicals:** Pesticides, herbicides, fungicides and fertilizers etc.
6. **Metals:** Mercury, lead, iron, zinc, nicket, tin, cadmium etc.
7. **Photochemical oxidants:** Photochemical smog, peroxyacetyl nitrite (PAN) etc.
8. **Municipal waste:** Sewage, solid waste etc.
9. **Radioactive waste:** Radioactive substances
10. **Noise:** Horns, loudspeakers etc.

There are several kinds of pollutions which pollute our environment. But the major types are: Air pollution, water pollution, land pollution, noise pollution etc.

AIR POLLUTION

Air is a mixture of gases and life cannot be sustained without it. Air is polluted when its quality and composition is changed. The release of low amount of pollutants into the air does not lead to any serious problem but when the concentration of pollutants in air becomes very high, it results into air pollution. Thus, the air pollution is defined as the undersirable change occurring in air causing harmful effects on environment, human beings and domesticated species. Such pollution is known as air pollution.

I. Sources

Air gets polluted largely due to the smoke produced by the automobiles, power plants, kitchens, and due to the large-scale burning of fossil fuel such as coal, diesel, petrol, kerosene etc. The different sources of pollution by which air becomes polluted are as follows:

1. **Fossil fuels:** The burning of fossil fuel produces carbon dioxide, carbon monoxide, sulphur dioxide, oxides of nitrogen, hydro-carbons, particulate matter and metallic traces. Coal produces a lot of smoke and dust while petrol and its products produce more of sulphur dioxide.
2. **Thermal power plants:** Most of the thermal power plants are coal based. The main pollutants are fly ash, soot and sulphur dioxide.
3. **Fertilizer plants:** Fertilizer plants produces oxides of sulphur, mostly come from sulphuric and phosphoric acid, particulate matter and fluorine. Ammonia, nitrogen oxides and hydro-carbons also released into the atmosphere from nitrogen based plants.

4. **Textile industry:** Pollutants from textile industry are cotton dust, nitrogen oxides, chlorine, naphthalene vapours, smoke and sulphur dioxide.
5. **Chemical and pesticide plants:** Chemical and pesticide plants produce different kinds of effluents. They also prepare caustic soda and produce chlorine gas.
6. **Steel plants:** Steel plants produce carbon monoxide, carbon dioxide, sulphur dioxide, fluorine and dust etc.
7. **Automobiles:** Exhausts of automobiles constitute about 60% of the air pollution by releasing compounds like carbon monoxide, oxides of nitrogen, hydrocarbons, particulate matter, smoke etc.
8. **Decomposition of organic wastes and municipal garbage:** These produces foul smelling gases which pollute the air.

II. Effects of air pollution

The air pollutants effect seriously the human beings. Some important effects of air pollution on living organisms are as follows:

1. **Death:** When the air gets polluted with poisonous gases, death comes immediately. Bhopal gas tragedy is a best example which happened on 2nd October, 1984. About 3,000 human being died, 5,000 paralysed and thousands of cattles, birds, dogs and cats died in one night in Bhopal, Madhya Pradesh. This mass death was due to the leakage of methyl isocyanate (toxic gas) into the air from an insecticide plant managed by Union Carbide Corporation,USA.
2. **Chlorosis:** This means the disappearance of chlorophyll from plants leaves. It is caused by the sulphur dioxide and fluorides present in the air.

3. **Necrosis:** The breakdown of cells is called necrosis. It is caused by sulphur dioxide, nitrogen dioxide, ozone and fluorides.
4. **Vomiting:** It is caused due to the presence of sulphur dioxide in the air.
5. **Respiratory disorders:** Air pollution, causes respiratory disorders. If the aldehydes are present in the air, it irritates the nasal passage and respiratory tract. Chlorine and phosgene cause pulmonary oedema.
6. **Nausea:** Hydrogen sulphide gas smells like rotten eggs and causes nausea.
7. **Coughing:** It is caused by several pungent smelling compounds and phosgenes in the air.
8. **Headache:** The headache is caused mainly due to the presence of sulphur dioxide in the air.
9. **Cancer:** This is caused by air pollutants like ash, soot, smoke, chromium, nickel and radioactive elements mixed in the air.
10. **Mutations:** Radioactive elements produce mutations. Ozone produces chromosomal aberrations.
11. **Cardiac diseases:** The cardiac diseases such as high blood pressure, coronary heart diseases, heart attack may be caused due the presence of cadmium in the air.
12. **Pneumonia:** It is caused by the breathing in too much of manganese particles present in the air.
13. **Acid rain:** Acid rain, one of the environmental problems, human society is facing at national and international level. We know that the oxides of sulphur and nitrogen are important gaseous pollutants of air. These oxides are produced mainly

by the combustion of fuels, smelters, power plants, automobile exhausts, domestic fires, industrial emissions etc. These oxides are swept up into the atmosphere and can travel thousands of kilometers. They stay longer in the atmosphere and are hydrolyzed into acids. Sulphuric acid and nitric acid are the two main acids, which get mixed with the rain water in the atmosphere and fall on to the ground as acid rain or may remain in the atmosphere as clouds and fogs.

Acidification of environment is a man-made phenomenon. The acid rain is infact a cocktail of sulphuric acid (H_2S0_4) and nitric acid ($HN0_3$) and the ratio of the two may vary depending on the relative quantities of oxides of sulphur and nitrogen emitted. The acid rain problem is dramatically increasing due to the industrialization. Acid rain has assumed to be a global ecological problem because these oxides travel a long distance and during their journey in the atmosphere, they may undergo physical and chemical transformations to produce more hazardous products.

Acid rain affects both the materials and organisms. It attacks building materials specially sand stone, limestone, marble, steel and nickel. There is a threat to the 'Taj Mahal' by air pollutants which come out into the atmosphere from Mathura Oil to Refinery. In plants, it leads to chlorosis or depigmentation of leaves. Acid rain increases the acidity of lakes and rivers. Acidity kills the fish, bacteria and algae. Because of acid rain, the aquatic ecosystems collapse into sterility. Acid rain increases soil acidity, this is affecting the terrestrial flora and fauna. The acid rain is spreading in the developing countries where the tropical soil is even more vulnerable than that of Europe. India is also facing

facing the problem of acid rain. Critical values of acid rain have been recorded in Delhi, Nagpur, Pune, Mumbai and Kolkata.This is caused due to the sulphur dioxide from coal based power plants and petroleum refineries. There is urgent need for proper and regular monitoring to provide timely warnings about acidification of our environment. According to a study of air monitoring section, Bhabha Atomic Research Centre, Mumbai, the average pH value of acid rain in Mumbai is 4.80, Hydrabad 5.73, Kolkata 5.80, Chennai 5.85 and Delhi 6:21. The situation may worsen in future due to increased installation of thermal power plants by National Thermal Power Corporation and subsequent increase in coal consumption.

14. **Ozone depletion and global warming:** In the atmosphere about 30 km above the surface of the earth, ozone molecules form a layer called ozone layer. This ozone layer prevents the penetration of harmful ultra-violet radiation from the sun and thus protects life on the earth. The depletion of this ozone layer by human activities may have serious implications and this has become a subject of much concern over the last few years. On the other hand, ozone is also formed in the atmosphere through the chemical reactions involving certain pollutants like oxides of nitrogen under the influence of ultra-violet radiations. The atmospheric ozone is now being regarded as potential danger to human health and crop growth.

$$NO_2 \xrightarrow[\text{UV radiation}]{\text{Solar radiation}} NO + O$$

$$\text{Atmospheric } O_2 + O \xrightarrow[\text{UV radiation}]{\text{Solar radiation}} O_3$$

Ozone: the destroyer: The ozone layer has two important and interrelated effects: (i) It absorbs ultra-violet radiation and thus, it protects the life on earth from the harmful effects of this radiation, (ii) By absorbing the ultra-violet radiation, the ozone layer heats up the stratosphere, causing temperature inversion. The effect of this temperature inversion is very interesting. lt limits the vertical mixing of pollutants, thereby causing the dispersal of pollutants over larger areas and near earth's surface. That is why a dense cloud of pollutants usually hang over the atmosphere in highly industrialized areas causing several unpleasant effects. The wastes spread horizontally relatively faster than slow mixing vertically, reaching all longitudes of the world in about a week and all latitudes within months. Therefore, very little that a country can do in protecting the ozone layer above it. The ozone problem is thus global in scope. The pollutants like chloro fluro carbons (CFCs) enter into the stratosphere and increase in harmful mutations. Enhanced ultra-violet radiation also impaired fish productivity. Ozone pollution is likely to become a major global problem during coming decades. We expect that the governments throughout the world will co-operate in dispelling the dangers posed by the global threat from ozone depletion in the stratosphere and ozone production near the earth's surface.

Global efforts: The first global conference on depletion of ozone layer was held in Vienna (Austria) in 1985. British team of scientists discovered a hole in ozone layer. As it remained there for years until it was converted into other products or it was transported back to the stratosphere. The stratosphere is regarded as sink, but these pollutants (CFCs) react with the ozone and deplete it. The ozone

near the earths surface in the troposphere creates pollution problems. Ozone and other oxidants *viz.*, Peroxy acetyl nitrate (PAN) and hydrogen peroxide are formed by the light dependent reaction between $N0_2$ and hydrocarbons. Ozone may also be formed by $N0_2$ under the influence of ultra-violet radiation. These pollutants cause photo-chemical smog. Ozone has adverse effects on human health. At higher level of ozone in the atmosphere protect us from harmful effects of ultra-violet radiations and it is harmful when it comes in direct contact with plants and animals on the earth's surface.

Depletion of ozone in stratosphere causes direct as well as indirect harmful effects. Since the temperature rise in the stratosphere is due to heat absorption by ozone. The reduction in ozone would lead to temperature change and rainfall failure on the earth. A series of harmful effects are caused by an increase in ultra-violet radiation. Cancer is the best known established threat to man. When the ozone layer becomes thinner or has holes, it causes cancers specially related to skin like melanomas. Around 6000 people die in the U.S.A. every year due to such cancers. The skin cancer patients are increasing by 7% in New Zealand and Australia. Other disorders are cataracts, destruction of aquatic life, vegetation and loss of immunity.

Apart from the direct effects, there are indirect effects also. Under greenhouse effect conditions, plants are exposed to ultra-violet radiation. They show a 20 to 50% reduction in growth and reduction in chlorophyll content. In India, New Delhi, Mumbai and Kolkata are the largest ozone producing cities. Mexico, Los-Angeles and Bangkok are the other cities which produce large amount of ozone. This gas protects the atmosphere (20 km above the earth

surface) but is deadly, when it is below this height, it is causing lung diseases. There was another International Conference on Ozone at Helesinki in May, 1989 to revise Montreal protocol. As many as 80 nations agreed to have a total ban on chemicals that cause ozone depletion by 2000 A.D. The agreement for CFC (Chloro-Fluoro-Carbon) elimination is needed as a major step towards environmental protection.

15. **Greenhouse effect:** Carbon dioxide is a natural constituent of the atmosphere, but its concentration is increasing in the air with an alarming rate. Carbon dioxide is released into the atmosphere by burning of fossil fuels for domestic pusposes, thermal power plants and industries. Carbon dioxide gas is confined to the troposphere. It allows the sunlight to filter through it to the earth's surface and to maintain energy balance. Excess of carbon dioxide in the air is removed by the plants and oceans. This maintains appropriate level of carbon dioxide in the air. If the envelope of carbon dioxide becomes thicker beyond its assimilation by plants and oceans, it stays in the atmosphere and prevents infra-red radiations from escaping into the outer space. As a result, temperature on earth's surface is increased. Carbon dioxide thus functions like the glass panels of a green house and the effect so produced is called 'Greenhouse effect'. The Greenhouse effect also causes global warming as the temperature of the earth's surface increases due to this effect.

    At present, the concentration of carbon dioxide in the atmosphere is 350 ppm but it may goes upto 450 ppm by 2040. Its increasing concentration may change the climatic conditions. Not only carbon dioxide is responsible for the global warming but

some other gases are also responsible for it to some extent. Such gases are collectively known as greenhouse gases. These gases include not only carbon dioxide, but methane, ozone, nitrogen oxide and synthetic chloro-fluoro-carbons. The consequences of greenhouse effects are change in temperature, melting of polar ice, climatic change, crop production and nutrient depletion.

III. Control measures of air pollution

The main sources of air pollution are motor vehicles, industries particularly their chimney wastes and fossil fuel (coal) based plants such as thermal power plants. Steps are taken to control the air pollutants, their sources and prevention as well as after their release in the atmosphere. Following are the control measures of air pollution:

A. Vehicular pollution: Some measures are to be adapted for the control of air pollution by motor vehicles. These are:

1. **To check emission of pollutant from vehicular exhaust:** This can be achieved by (i) using new proportion of gasoline and air, (ii) more exact timing of fuel feeding, (iii) using gas additives to improve combustion, (iv) updating the engine design or install device to improve combustion with the existing engine design (use of catalytic converters).
2. **To control evaporation of fuel from tank and carburetter:** This can be done by (i) collection of vapours with activated charcoal when the engine is turned off and its ignition when the engine is started, and (ii) developing the low volatile gasoline which does not evaporate easily.
3. **Use of filters:** The use of filters captures and recycle the escaped gases in the engine and

should control the emission of these hydrocarbons.

4. **Control through law:** The enforcement of some emission standards through motor vehicle act and other acts for the design of engines etc. can be imposed.

B. **Industrial pollution:** To check air pollution by industrial and power plant chimney wastes, one must use devise for measuring the removal of particulate matter and gaseous pollutants from the wastes. The removal of particulate matter involves their collection under the influence of different force. The equipment used for their removal are: (i) Cyclone collectors and (ii) Electrostatic precipitators (ESPs). Thus, we have to generate the control technology. At present, there are few power plants and industries that have installed the requisite ESPs.

1. **Cyclone collectors:** The waste gas containing particles are subjected to centrifugation. The suspended particles move towards the wall of cyclone body and then to its bottom and finally discharged out. The cyclone collectors remove about 70% of the particles.
2. **Electrostatic precipitator:** To remove the particles from gas stream, the electrical forces are applied within the chamber of the precipitator, the suspended particles become charged or ionised and they are attracted to the charged electrodes and removed. Electrostatic precipitator can remove 99% of the particulate pollutants from chimney exhaust. Electrostatic precipitator work very well in power plants, paper mills, cement mills etc.

C. **Gaseous pollutants:** These can be removed by three methods: (i) Wet system, (ii) Dry system and (iii) Wet-dry system.

(i) **Wet system:** In this system washing towers are used in which alkali fluid circulate continuously. This liquid react with sulphur dioxide to produce a precipitate.

(ii) **Dry system:** Here the gas pollutants are allowed to react with an absorbent under a dry phase.

(iii) **Wet-dry system:** In wet-dry system, the water in the absorbent reacts with the acid components. This offers an alternative to traditional wet process used for de-sulphurization of fuel gases from coal fired boilers.

D. **Control through law:** All pollution can be controlled by framing legislation. Like motor vehicles standard should be enforced by appropriate act for industries also. There are other conditions that could be enforced by law.

E. **Public awareness:** An important aspect is to create public awareness about the pollution hazards.

F. **Plantation:** Plants removes pollutants. People should be educated by mass media and by other means about the importance of trees and plantations. More and more trees should be planted.

WATER POLLUTION

Like air, water is also one of the most important and precious natural resource on the earth. The water is covered over 3/4th of the earth area. It occurs in solid, liquid and gaseous form. It is a need of every living organisms. We depend on water for irrigation, industry, domestic needs, shipping, aquaculture and for sanitation and disposal of waste etc. Water-bodies like ponds, lakes, streams, rivers, seas, oceans have become polluted due to industrial wastes, urbanization and other man created problems. Many rivers in the world receive heavy influx

of sewage, domestic waste, industrial effluents, agricultural wastes etc. which contain substances varying from simple nutrients to highly toxic chemicals. In our country, all the 14 major rivers have become polluted. Some of them like Godavari, Ganga, Gomati, Cauvery, Narmada and Mahi are facing problem of pollution. Since water has unique properties of dissolving and carrying in suspension a huge variety of chemicals. It gets contaminated very easily.

What is water pollution? It may be defined as the addition of any substance into water and changing the physical and chemical properties in anyway which may harmfully affects the life activities of living organisms including human beings and other species. Normally, water is never pure in a chemical sense. It contains impurities of various kinds in dissolved and suspended form. The dissolved, gases like hydrogen sulphide, carbon dioxide, ammonia, nitrogen, dissolved minerals (like calcium, magnesium, sodium salts), suspended matter (clay, silt and sand) and even micro-organisms are included impurities. These are the natural impurities. Polluted waters, however, are turbid, unpleasant, bad smelling and unfit for drinking, bathing and washing and for anyother use. Polluted water causes diseases *viz.*, cholera, dysentry, typhoid etc. The water pollution has now become one of the most serious problems throughout the world, particularly in the developing countries.

I. Sources

The major sources of water pollution are: (i) Sewage and other wastes, (ii) Agricultural discharges and (iii) Industrial effluents and wastes from chemical industries, thermal power plants and nuclear power stations. These sources of pollution carry a variety of pollutants that enter into our water bodies and make them polluted. All these sources of water pollution are explained as follows:

1. **Sewage and other wastes:** Sewage is the waterborn waste derived from night soil and domestic waste and wastes from animal or food processing plants. It includes human excreta, soap, detergent etc. These enter into the water body and makes them polluted. There is uncontrolled dumping of wastes in rural areas, towns and cities into ponds, lakes, streams or rivers. Due to their accumulation in large quantities, they are not recycled and their regulatery capacity is lost. The decomposition of these wastes by aerobic microbes also decreased due to higher levels of pollution. Because of decomposition of wastes, biological oxygen demand level increases.

   Phosphates are the major ingredients of most detergents. They favour the luxuriant growth of algae and forms algal bloomes in the water bodies. Algal blooms consume most of the available oxygen from water because of which, the level of oxygen decreases which results into the production of foul smell upon decay. Some decomposing plants produce toxins like strachnine which kill the animals including cattle. Discharge of sewage and other wastes in water results into (i) depletion of oxygen level of water and (ii) stimulation of algal growth.

2. **Industrial effluents:** A wide variety of inorganic and organic pollutants are discharged in the effluents from breweries, tanneries, dying textiles, paper and pulp industries, mining operations etc. The pollutants includes oil, grease, plastics, suspended solids, phenols, acids, salts, dyes, cyanides, DDT, and other toxins etc. Cadmium, copper, chromium, mercury, lead etc. are the heavy metals in effluents discharged from the industries. Scientists have reported that about 180 million litres of toxic effluents are discharged into the Periyar river every day by the industrial units in the Cochin area of

Kerala. The toxicants dumped into the river are acids, alkalies, fluorides, free ammonia, insecticides, and dyes etc. The backwater system also received a considerable proportion of pollution load directly.

3. **Agricultural discharges:** These discharges include chiefly the chemicals used as fertilizers and pesticides used in agriculture. Their discharges reach into the water bodies. As compared to the other countries, India has relatively a low use of these chemicals. Fertilizers, *viz.*, N,P,K along with domestic waste (sewage) make water bodies nutrient rich and become more productive. This phenomenon called as eutrophication. Due to this, oxygen level of water decreases whereas, CO_2 level increases. It causes death of fish and other animals, owing to which clean water body turns into a stinking drain.

   Pesticides are the chemicals used for killing the plants and animal pests. It is a general term that includes bactericides, fungicides, nematocides, insecticides and also the herbicides or weedicides. However, there is a wide range of chemicals used as pesticides and herbicides. But most of them are harmful which do not degrade or degraded very slow in nature. The hazardous biocides cause considerable harm since their effects are cumulative. Most nations have banned the use of some of these chemicals. The long range effects of such chemicals are in fact threat to our ecological security. For instance, if DDT enters into a pond, or a lake, it is taken up by the plants and phytoplankton in the pond, then reaches to zooplankton then to fish and finally in the body of birds who eat the fish. Not only DDT but more threatening is that the concentration of DDT continuously increases in successive trophic levels (various forms of living organisms) in a food chain. This phenomenon is known as biological

magnification or biological amplification. This is the reason why our food grains as wheat, rice, vegetables and fruits today contain varying amount of pesticide residues which have become their integral part. They cannot be removed by washing or by other means.

4. **Industrial wastes:** The two chief pollutants are heat and radioactive substances. These are the wastes chiefly from power plants: thermal and nuclear, which use large quantities of water. Some other industries also give waste water after use. Nuclear power plants are the source of radionuclides. The quantity of waste water is higher in the thermal power plants in the country. This waste water is retuned after use at very high temperatures to the streams, river or lake and affects entire aquatic life in these water bodies. This contributes to thermal pollution and some plants and animals are killed by the very hot water.

II. Effects of water pollution

Water pollution causes several effects on the body of human being and other living organisms. Some of them are as follows:

1. **Minamata disease:** This disease was caused by the mercury poisoning. It is characterised by crippling and death. This disease first appeared in a coastal town, Minamata in Japan during 1953. It was caused due ot the consumption of mercury affected fish. Many peoples suffered and died. It is now occurring in Japan, Swedan and other countries.
2. **Diarrhoea:** It is a water borne disease. When the polluted water is taken by the people, it results into diarrhoea. The contaminated water contains mercury, cadmium, and cobalt. This disease is mostly observed during monsoon.

3. **Algal bloom formation:** Input of large amount of nutrients in the water-bodies results into the algal bloom formation. The blooms cause mass mortality of fishes and aquatic organisms.
4. **Water-borne diseases:** Diseases like jaundice, cholera, typhoid etc. are transmitted through the polluted water contaminated with sewage.
5. **Prevention of oxygenation:** Oil-spilled on the surface of water prevents the water oxygenation. This reduces the respiration and metabolism in the aquatic organisms.
6. **Production of crops:** Polluted water affects the quality and productivity of the crops.
7. **Biological oxygen demand:** BOD is the amount of oxygen required by the micro-organisms for the decomposition of organic matter in water. Increased biological oxygen demand lowers the contents of dissolved oxygen in water causing suffocation and death of aquatic fauna.

III. Control measures of water pollution

Biodegradable pollutants are not only responsible for the water pollution. Beside these, a substantial pollution load is contributed by non-degradable or slow degrading pollutants such as heavy metals, mineral oils, biocides, plastic materials etc. which are dumped into the water. The bio-degradable pollutants may be controlled by their treatment for recycling and reuse. The non-degradable toxic substances can be removed from water by suitable methods. Besides, some standard conditions and requirements are to be legally enforced by the government through acts. Various methods suggested by the scientists for the control of water pollution are as follows:

1. **Stabilization of the ecosystem:** This is the most scientific way to control water pollution. The basic

principle involved in this method is the reduction in input of wastes, thus, control at source such as harvesting and removal of biomass, trapping of nutrients, fish management and aeration be implemented. Biological and physical methods are used to restore diversity and ecological balance in the water body to prevent pollution.

2. **Recycling and reutilization of waste:** Various kinds of wastes which include industrial effluents, sewage of municipalities and other systems, thermal power plants, waste water etc. may be recycled for beneficial use. For example, urban waste (sewage/ sludge) may be recycled to generate cheaper fuel, gas and electricity. National Environmental Engineering Research Institute (NEERI), Nagpur has developed a technology for the management of radioctive wastes and chemical wastes of atomic power plants. NEERI is also involved in the development of suitable technology for waste water reclamation through aquaculture, utilization of domestic and industrial waste water in agriculture and detoxification of phenol and cyanides in waste by biological means. It is also observed that one distillary in Gujarat is able to treat 4,50,000 litres of waste daily and generates energy equal to that produced by 10 tonns of coal.
3. **Removal of pollutants:** The various kinds of pollutants such as radioactive, chemical and biological pollutants are present in the water body. They can be removed by the appropriate methods *viz.*, adsorption, electrolysis, ion exchange, reverse osmosis etc. Reverse osmosis is based on the removal of salts and other substances by forcing the water through a semipermeable membrane under pressure exceeding the osmotic pressure. Due to this, flow occurs in reverse direction. This method is commonly

used to desalinate the brackish water and also used for purifying the water from sewage. Council of Scientific and Industrial Research, New Delhi has suggested a plan for the successful removal of different pollutants from water.The pollutants which can be removed are:

a. **Mercury:** This could be removed from chlor-alkali effluent plant by using mercury selective ion exchange resin.
b. **Ammonia:** It can be removed from waste water of industry by ion exchage technique.
c. **Phenolics:** These could be removed from waste waters of pulps and paper mills, carbonization plants, petroleum refineries, tanneries and resin plants by the use of polymeric absorbents.
d. **Decolorization of water:** The waste water from printing and textile industries could be decolorized by an electrolytic decomposition technique.
e. **Sodium salt:** This can be removed by the reverse osmosis method. Very recently researches of some American Laboratories (reported by the Wall Street Journal) have claimed to use solar power for cleaning up polluted water cheaply.

4. **Treatment of industrial effluents:** The industrial effluents should be cleaned before they are discharged into the any water body. Every industry should set up industrial waste treatment plant individually or collectively. This will minimize the pollution to a great extent.

In this way, we can treat and control the water pollution and save the life as well as water on earth from pollution. It may be mentioned here that cost of treatment of pollution is very high. Therefore, the best way is to prevent the pollution at source.

NOISE POLLUTION

We all hear sound produced by vehicles, trains, aeroplanes, industries, community functions etc. All these produce noise which is most dangerous pollutant of man's environment. Noise has become a permanent part of our lives in these days. Noise not only harms to our brain but it also affects the important internal organs of the body. It not only causes irritation but constricts our arteries, increases blood pressure and heart beats etc.

The noise can be defined as 'the unwanted sound or unpleasant sound which causes discomfort'. It may also defined as the wrong sound at the wrong place at the wrong time. The unwanted sound forced into the atmosphere leads to health hazards. Noise is measured in decible (dB). Pain is usually felt at 145 dB. People begin to complain when unwantd sound reaches a level of upto 100 dB.

In the past, the noise was limited to the industries only, but these days there has been a rapid industrial growth, population explosion, heavy traffic, urban crowding etc. All these have added the noise nuisance in the environment. Besides these, social and religious functions increase the gravity of situation.

I. Sources

There are numerous sources of noise pollution. In the broad sense, these may be classified into three categories *viz.*, (i) Industrial machinery noise, (ii) Traffic noise, and (iii) Community noise.

(i) **Industrial machinery noise:** Major industries run with heavy machineries which produce noise. Persons working in such industries are constantly exposed to high level of noise.

(ii) **Traffic noise:** In urban areas, trucks, buses, cars, trains, aeroplanes etc. produce noise at different levels.

(iii) **Community noise:** The community functions also cause noise pollution. These functions *viz.*, festivals, marriages, political elections, religious gatherings and so on are the main causes of community noise. Schools, libraries, study centres and hospitals are the victims of such noise. The radios, microphones, sound systems in residential areas also cause noise pollution.

II. Effects of noise pollution

The effects of noise pollution may differentiated into two catgories: auditory effects and non-auditory effects.

1. **Auditory effects:** These include auditory fatigue and deafness.
   (a) **Auditory fatigue:** It appears at 90 dB and it may be associated with side effects such as whistling and buzzing to ears.
   (b) **Deafness:** It is caused due to continuous noise exposure. Temporary deafness occurs at 400-600 hz. Permanent loss of hearing occurs at 100 dB. Mumbai, Delhi, Kolkata and Chennai are noisy cities in India. Many persons exposed to unwanted noise have risk of deafness.
2. **Non-auditory effects:** The non-auditory effects are as follows:
   (i) **Interference with speech communication:** A noise of 50-60 dB commonly interferes with speech.
   (ii) **Annoyance:** Some persons express great annoyance at even low levels of noise as caused by crowed, highway traffic and radio etc. These cause ill temper, pricking etc.

(iii) **Loss of working efficiency:** Because high level noise causes tiredness and those doing mental work may put to deterioration in their efficiency or even complete loss of ability to work.

(iv) **Physiological disorders:** Noise pollution develops a number of physiological disorders. These are neurosis, anxiety, insomnia, hypertension, behaviourial and emotional stress, fatigue etc. Thus, noise affects the overall mental and physical health of a person. Continuous noise causes an increase in cholesterol level which may cause heart disease. There may be still births and usually low weight children are born to mothers living near airport. Noise pollution also causes incidence of peptic ulcers. Supersonic aeroplanes create shock waves called sonic boon which produce a starter effect and can be more harmful than a continuous noise. The sonic boon may spread in the area of 10-80 miles and when it hits the ground, it damages the window pans and building structures. This may also fasten the human heart beats.

III. Control measures of noise pollution

As noise pollution is seriously affecting the living organisms including human beings, it is necessary to control noise pollution. There are following ways to control and reduce noise pollution.

1. **Control at source:** This can be done by (i) designing and fabricating silencing devices in air- craft engines, automobiles, industrial machines and home appliances, and (ii) by seggregating the noisy machines.
2. **Transmission control:** This can be achieved by covering the room-walls with sound absorbers as acoustic tiles and the construction of enclosures around the industrial machinery.

3. **Masks:** The persons working with noisy machines should wear ear masks and ear plugs etc.
4. **Plantation:** Plants absorb the sound energy and thus act as a buffer zone. In social forestry, trees should be planted along the highways, streets and other places where there are industries and factories. The good trees for the plantation are ashok, neem, tamarind etc.
5. **Education:** Public must be made aware and educated about noise nuisance adequately through news media, mass media, lectures and other programmes. We must consider noise pollution as a part of our routine life and its impact on human beings.
6. **Control by law:** Noise pollution can also be controlled by laws. Noise producing industries and factories as well as railway stations, airports must be away from cities. Silence zones must be created near schools, hospitals and there should be control on loud-speakers at public places enforced by law. Adequate restrictions must be put on unneccesary use of horns and vehicles plying without silencers. Motor vehicles act is already in existence and it is followed in many countries including India. The Indian Penal Code also has provisions on the control of noise pollution.

In the last, noise pollution is a major environmental pollution and it is affecting our life seriously. So we must try to keep control on noise pollution.

PESTICIDE POLLUTION

Now a days many farmers are using pesticides to control the animal pests damaging their crops which results into

a good yield. Its use in large proportion causes pollution which is called as pesticide pollution. It may be defined as, any undersirable change in the environment brought about by the pesticides which is harmful to human being is referred as pesticides pollution.

Pesticides are the chemical compounds which are specially designed and manufactured to destory animal pests. They have proved tremendously beneficial to human populations in reducing or destroying the rats, insects, snails and other animals which transmit diseases or destroy agricultural crops, damage homes and stored products and affect human health and welfare directly or indirectly. The pesticides which cause pollution are insecticides, rodenticides, fungicides, herbicides, fumigants, nematicides etc.

I. Sources

There are various sources of pesticide pollution by which our environment gets polluted.These sources are:

1. **Direct spraying:** Pesticides are applied by spraying over the crop fields. About 30 to 50% of the sprayed insecticids are carried away by the wind and the residues fall out into the terrestrial or aquatic ecosystems either in the vicinity or away from the spraying site.
2. **Run-off:** Pesticides are carried away by the surface run-off when there is a heavy rainfall, soon after the pesticides applied or even afterward.
3. **Atmosphere:** Pesticides reach into the atmosphere in many ways *viz.*, spraying drift, volatilization and dust erosion. During the precipitation, they are washed into the ecosystem.
4. **Direct discharging into the water:** Pesticides are discharged from pesticide factories or from woolen mills which use pesticides in the processing of wool.

II. Effects of pesticide pollution

The long range effects of pesticide are infact a threat to our ecological security. According to Pearson (1985) pesticides are related with deaths in the developing countries. It is estimated that there are 10,000 deaths every year and almost every year 1.2 millions people are suffering from acute pesticide poisoning. Some of the most toxic pesticides are DDT (dichloro diphenyl trichloroethane), BHC (benzene hexachloride), chlordane, heptachlor, aldrin, endrin and PCBs (Polychlorinatedbiphenyls). An indiscriminate use of biocides has made them an integral part of our biological, geological and the chemical cycles of the earth. They are, therefore, found everywhere.

If DDT is taken as an example for studying the effects of pesticides, first it enters into a pond, lake, reservoir etc. then it is taken by the phytoplankton in the pond, then it reaches to zooplankton which feed on the phytoplankton then to fish which eat the zooplankton and finally in the body of birds or man who eat fish. In this way DDT enters into the food chain. This is the reason why our food grains as wheat and rice, vegetables, fruits and even mother's milk today contain varying amount of pesticide residues. They cannot be removed by washing or any other means. Besides DDT, there are heavy metals like lead, mercury, copper etc. also show similar behaviour in the food chain.

The danger of long term consumption of pesticide residues in food is far more serious than acute poisoning from the national health point of view. There is evidence that chronic accumulation of pesticides played a role in kidney malfunctioning, excess of amino acids in blood and urine, brain and blood abnormalities etc. Thus, pesticides cause serious damage to living organisms.

I. Control of pesticide pollution

When we study the effects of pesticide pollution, certain measures are suggested by the ecologists to control the pesticide pollution. These are given below:

1. **Control on use:** Only selective or target pesticide must be used in required dose *i.e.*, in appropriate quantity.
2. **Pesticide education:** Agriculturists must be trained for using the pesticides. They must know the effects of pesticide. Education should be given to both the public and farmers for the use of pesticide.
3. **Research activities:** Scientific work must be carried out on the farms to know the effects of pesticide which are used by the farmers and which will be used in future *i.e.*, use of new pesticide.

SOLID WASTE POLLUTION

In nature many things are thrown out side after their use. These includes bottles, crockeries, plastic containers, polythene, paper and other packing materials. These form a part of garbage and such things creates undersirable or harmful effects in the environment which result into pollution and is referred as solid-waste pollution.

I. Sources

Besides the garbage, other things like automobiles spare parts, machines and cycles parts house-hold waste etc. that are thrown as junk are important sources. The wastes from building material (during construction and demolition), sludge, dead animal skeleton, heaps of crop residues also contribute to solid waste pollution. Electronic waste has become a new class of solid waste.

II. Effects of solid waste pollution

Solid-wastes are causing much problem in developed affluent world, such as USA and European countries. There have been a regular voluntary companies for cleaning the environment from solid waste. In India also several millions tonnes of solid waste is dumped along highways and other places in large cities such as New Delhi, Mumbai, Kolkata, Chennai, Ahmedabad, Jaipur etc. An average of over 2 millions tonnes of solid waste is generated in class I cities every year, whereas, in class II cities, it is about 0.25 million tonnes/year. There is a big problem of disposal of these wastes especially in the developed countries where labour is very expensive. In India most of junk is purchased by hawkers and resold after earning some profit.

III. Control of solid waste pollution

To solve these problems, many technologies have been developed to recycle the solid wastes. Newspapers, plastic-cans and other wastes may be easily recycled. Metallic components of vehicle spares may be recycled by cheap methods. However, there is problem of recycling of heavy metals, plastics, nylon, polythene etc. To control this solid-waste pollution, the following methods may be taken up:

1. Recycling of wastes should be done to recover usable material.
2. Burning of solid wastes and utilizing heat to warm residential units and generation of electricty.
3. Composting organic waste for the preparation of manure and biogas.

Thus, the solid waste pollution is also a major environmental pollution in the developed world. It must be in control for the healthy environment.

Marine pollution

All that carried out by the rivers ultimately ends up in the seas. On their way to sea, rivers receive huge amount of sewage, garbage, agricultural discharge, pesticides including heavy metals. These all are added to the sea. Besides these, oil and petroleum products and dumping of radio-nuclides waste into sea also cause marine pollution. Hydrocarbon and benzopyrene accumulate in food chain and consumption of contaminated fish by man may cause cancer. Detergents used to clean up the spill are also harmful to marine life.

Mercury pollution

Mercury enters into the water naturally as well as through industrial effluents. It is a potential hazardous substance. Both inorganic and organic forms of mercury are highly poisonous. Methyl mercury gives off harmful vapours. Mercury was responsible for the Minamata disease, which had caused several deaths in Japan and Sweden. The tragedyzzhad occurred due to the consumption of mercury contaminated fish (27 to 102 ppm, average 50 ppm) by the villagers. The source of mercury was $HgCl_2$ which is used as a catalyst in some industry. In Sweden, many rivers and lakes are already polluted due to the wide spread use of mercury compounds as fungicides and algicides, in the paper and pulp industries and agriculture. Paper and pulp industries in Japan and Canada also cause mercury pollution. Effluent from industries which are making switches, batteries, thermometers, fluorescent tube lights and high intensity street lamps also contain mercury.

Lead pollution

Lead poisoning is common to adults. The chief source of lead to the water are the effluents of lead and from lead

processing industries. Lead is also used in insecticides, food, beverages, ointments and medicinal mixtures for flavouring and sweetening. Lead pollution damage the liver and kidney, reduce haemoglobin percentage in the blood, bring about mental retardation and abnormalities in fertility and pregnancy. Lead poisoning also causes constipation and abdominal pain etc.

Fluoride pollution

Fluorine is regularly present in the water and soil besides the air. In nature, it is found as fluoride. The crop plants grown in high fluoride soils had a fluoride content as high as 300 ppm. Food grains obtained from such soils contain rich amount of fluoride. Prolonged intake of fluoride containing water, stiffens the bone joints, particularly spinal cord. Fluoride has an affinity with calcium and thus gets accumulated in the bones, resulting to the molting of teeth, pains in the bones and joints, outward bending of legs from knees. Fluoride level more than 0.5 ppm over 5-10 years results in fluorisis terminating in crippling or paralysis. In the water of most of the villages of Rajasthan and Maharashtra, fluoride level is higher than the permissible limit of 1 mg/litre of water. Cattle grazing around fluoride sources such as ceramic rocks, phosphate fertilizer plants and aluminium factories often develop fluorosis. The toxic effects are staining,molting and aberrations of teeth. High fluoride level in bone and urine, decreased milk production and causes lameness in animals.

QUESTIONS

1. What is pollution? Give an account of the different environmental pollutions.
2. Explain the air pollution alongwith its various sources, effects and control measures.

3. Give an account of the water pollution.
4. Write short notes on:
   A. Acid rain
   B. Ozone depletion
   C. Greenhouse effect
   D. Pesticide pollution
   E. Solid waste pollution
   F. Noise pollution

19

NATURAL RESOURCES AND THEIR CONSERVATION

Nature is a gift of God. Nature is so kind to human beings. Since its appearance on the earth surface, man has been dependent on nature for its livelihood. He needs plants and animals for food. In the initial stages of economic development, man identified these natural gifts and learnt to use them. Everything which comes from the nature has some utility for man but its proper utilization is possible only on availability of appropriate technology. Natural resources like land, water, forest, sun, wind etc. were present at that time before the origin of man. When the man came on the earth, he learnt many things from nature. But this took a long duration. Within this period, man could learn to cultivate the land, grow crops by protecting different plants and run the wind and water mills by using wind and water energy. Similarly, coal and mineral oil were present below the earth's surface but he had no means to utilize them. Hence, these natural materials turned into resources and when the technology was developed, they were made available for use by mankind.

What are natural resources? Wood is used for making furniture and other things. It is also used as fuel. Cotton is used for cloth making. These change their forms substantialy from the raw materials to finished products.

The resources, thus, can be defined as any material which can be transformed in such a way that it becomes more valuable and useful. Such materials called as resources. These resources are available in nature and can be made useful to the mankind. The natural resources are land, water, minerals, coal, forest, wildlife etc.

What are the types of natural resources? The natural resources are classified in several ways, like based on their utility and origin. Based on their utility, the natural resources are soil, forests, fish, land, water, wild life and energy resources. Based on their continual utility, the natural resources are renewable and non-renewable resources. The resources which can be renewed along with their exploitation are always available for use. Hence, they are called renewable resources. For example, forests are the renewable resources. The resources which can not be renewed are known as non-renewable resources *e.g.*, coal, petrol and minerals etc.

Based on their origin, the natural resources may be classified as biotic resources and abiotic resources. Biotic resources are obtained from the biosphere. Forest and its products, crops, birds, animal, fish and other marine forms are the examples of biotic resources. Coal and mineral oils also belong to this category as they are originated from the organic matter. Resources composed of non-living inorganic matter are called abiotic resources. Land, water, minerals are the abiotic resources. Some abiotic resources are found as nodules of copper and manganese in oceans.

Natural resource conservation and sustainable development

All the developing countries in the world have started realizing that there is a conflict between environment and development. The problem of conservation of natural resources arises essentially from three factors *viz.*, (a) population expansion, (b) one sided application of

technology to achieve certain goals, and (c) lack of control over the use of land. In this way, population, technology and land use contribute to the environmental crisis. Ever increasing human population resulted into expanding needs of man. With the scientific progress and technology, the development of man started with utilizing natural resources at a much greater scale.

Continuous increase in population results in an increasing demand for resources. This creates a critical situation when the non-renewable resources may come to an end after some time. There must be some sort of balance between the population growth and the utilization of natural resources.The non-availability of resources and their price rise are having an adverse effect on the economics of countries all over the world. It was found that there is no enough water for agriculture and industry, whereas, in other areas, there are problems of water logging due to over-irrigation. In some countries, much of underground water is utilized for food grain production. This has resulted in lowering of water table. In this way, there is need of conservation. Therefore, it is essential to conserve plants, animals and microbial wealth. There is an urgent need to conserve the biological diversity. Thus, the conservation of natural resources can be defined as the management of natural resources for the benefit of all life of the biosphere including humankind, so that it may yield sustainable benefit to the present generation while maintaining its potential to meet the needs and aspiration of the future generations.

Living resource conservation has three main objectives: (a) to maintain essential ecological processes and life support systems, (b) to preserve biological diversity and (c) to ensure sustainable utilization. Therefore, the conservation of natural resources makes important contributions to social and economic development.

There are two main categories of conservation of living resources *viz.*, *in-situ* conservation and *ex-situ* conservation.

***In-situ* conservation:** In this type of conservation, there is a conservation of genetic resources through their maintenance within a natural or even human made ecosystems in which they occur. This is an ideal system for the conservation of genetic resources. National parks, sanctuaries, natural reserves, natural monuments, cultural landscapes, biosphere reserves etc. belongs to this type of conservation. This type of conservation is not predictable for domesticates.

***Ex-situ* conservation:** *Ex-situ* conservation means conservation of living natural resources outside their habitat by perpetuating sample populations in genetic resource centres,zoos,botanical gardens,culture collections etc. or in the form of gene pools and gamete storage of fish, germplasm bank for seeds, pollens, semen, ova, cells etc. Plants are more readily maintained than animals. In this type of conservation, seed banks, botanical gardens, pollen storage, tissue culture and genetic engineering, play an important role.

Mrs. Indira Gandhi, Late Prime Minister of India had emphasized that our ancient care, conservation and worship of trees and animals while launching the 'World Conservation Strategy' in India on 6th March, 1980. In her own words, "the interest in conservation is not sentimental but the rediscovery of a truth well known to our sage. The Indian tradition teaches us that all forms of life, human beings, animal and plants are so closely linked that disturbance in one gives rise to imbalance in the others".

To realize the concept of sustainable development, abundant biological resources should be managed to allow sustainable use and endangered or declining biological resources should be protected from unsustainable utilization. Many experts believe that societies have failed to the value of environment and services it renders. The world ecosystems are highly complex, dynamic and often

unpredictable. Finding sustainability requires constant observation, careful analysis and regular correction. A good indicator should also be able to indicate what steps ought to be taken to improve performance in implementing a plan. Indeed, a good plan should be able to determine the choice or use of suitable indicators.

WATER RESOURCES

Water is an important resource like land. An important use of water in our country is for irrigation. Besides water is also required in large amount for industrial and domestic consumption. Unlike land, availability of water varies from place to place and time to time. A bulk of rainfall is confined to 3-4 months (July-October). As such, a large part of the country lacks surface water supply for a greater part of the year. Surface flow in our country takes place through 14 major river systems *viz.*,Brahmaputra, Ganga, Godavari, Krishna, Mahanadi, Cauvery, Narmada, Periyar, Tapti, Brahmani, Indus, Sabarmati, Suvarnarekha, and Mahi. About 85% water flows out through these rivers. During dry months, there is scarcity even in places like Cherapunji and Konkan receiving heavy rainfall. Due to unequal distribution of rainfall, we face problems of flood and famine in some parts every year. Our groundwater resources are abundant only in northern and coastal areas. In other parts its supply is not even adequate.

I. Water resource management

There are many central and corresponding state organizations concerned with specific aspects of water resource management. Some of them are: Central Water Commission: for surface water; Central Ground Water Board: for ground water; Indian Meteorological Department: for precipitation; Central Pollution Control Board: for water quality;Ministry of Agriculture and ICAR:

for water use in agriculture; Department of power: for hydroelectric power; Department of forests: for watershed management; Department of environment, forests and wildlife: for environment impact assessment and Central Public Health and Environmental Engineering: for water supply, sanitation and sewage disposal.

Water management needs urgent attention and is divided between atleast 8 agencies. Unfortunately, none of these agencies give much priority to water conservation except for the central water communities to some extent. The conservation of water resources is very important for maintaining life.

II. Conservation of freshwater resources

The demand for freshwater supply is increasing rapidly due to over population. An acute crisis is expected to follow soon in some regions of the world. The shortage of water supply makes many localities barren and devoid of life. Fertile lands become desert. Conservation of freshwater is, therefore, an absolute necessity today. Otherwise the tomorrow will be grim, drier and barren. A number of action plans have been undertaken to minimize the wastage of freshwater resources and to make more efficient use of available water. The conservation of freshwater resources can be made in the following manner:

1. **Recycling of water:** For almost all spheres of human activity more water is drawn than the amount actually needed. Much of the surplus water is returned to surface flow in impure state. A little care can reduce the over consumption. We waste the water because of its easy availability. Power generation is another sphere of human activity where a large amount of water is required. Most of it is used as coolant (about 90 to 95%). The heated water from thermal power plants may be used again

for other purposes. Agricultural run off from fields can be used to irrigate cropland down the stream. Thus, recycling and reuse of water will help developing the water economy.

2. **Development of an efficient distribution system:** Water resources are not distributed evenly. Some localities have plenty of water and others have little of it. Therefore, the transport of water from one place to another becomes an essential part of water conservation strategy. Many river basins have plenty of water which flows down to the sea. This surplus water can be diverted to the drier regions through an efficient system of canal and pipes. The surplus of one basin can be used to make up the deficit of another.
3. **Reduction of pollution and recycling of water:** Pollution spoils huge quantity of water. All possible efforts should be undertaken to divert waste water to some treatment plants instead of releasing them into surface waters, while treated water can be safely discharged into the water bodies. It may also be recycled when there is a more need.
4. **Enhancement of storage capacity:** We can store the rain water in tanks and other reservoir for use during the summer season. This can be made possible by embankments and dams which check the flood flow and detain water for longer duration on the land surface. However, surface storage of water is risky and costly venture. The pressure of standing water body enhances the seismic activity which may be precipitated as an earthquake. Small stop dams and check dams are also useful in storage of surface water and recycling ground water.
5. **Improvement of underground storage capacity:** The underground storage capacity of earth

can be improved by plantation. The plants provide an effective cover over the soil surface. Plants obtain mass of their water from soil moisture and keep their surrounding cool and humid, thereby, preventing excessive loss of water through evaporation. They also check the flow of water. As a result, more water percolates down. In dry season, there is an equally rapid loss of water from the soil in the absence of plant cover.

6. **Augumenting existing supplies of freshwater:** Many regions of the world with scanty rainfall have no other choice but to supplement their water supply by some other means.This can be done by: (a) desalination of sea water, and (b) making artificial rain.

   (a) **Desalination of sea water:** A huge storage of water exists in oceans. Only if the salt content of sea water is removed, we can use this water for our consumption. This is possible only by the process of desalination. In many developed countries, there are such desalination plants, which are being operated by the solar energy. However, these plants are very expensive.

   (b) **Making artificial rain:** In many countries, the artificial rain is made by the group of scientists. In this process, small particles of chemicals like silver nitrate ($AgN0_3$), sodium chloride, dry ice (solid carbon dioxide) etc. are injected into the thick layer of clouds (cumulus clouds) around which moisture condenses and droplets of water sink down as rain. In a number of countries, active experiments are being carried out in this direction. Generally, such experiments are necessary when there is scarcity of water or delay in the starting of monsoon.

DEFORESTATION

It is a major environmental problem. Deforestation means destruction of forests. Destruction of biotic potential of land leads to desertification. Such problems arises due to the over grazing of cattles, felling of trees in indiscriminate manner and over-exploitation of land resources. The devastating effects of deforestation in India include soil, water and wind erosion, estimated to cost over 1,64,000 million every year. According to a global survey, about 1/5 of the earth land was covered with closed forests and a canopy cover 20% or more, but at present, this is reducing very fast due to the deforestation. Extensive deforestation has been taking place in the developing countries. In South-East Asia, the problem of deforestation is worse. In India, according to the National Policy (1952), a forest cover 33% was to be maintained. However, survey conducted in 70's found a forest cover of about 22.7% only. The reduction of forest has been rapid during the last few decades. We are loosing our forest wealth at the rate of 1.3 millions ha per year. Deforestation has a major impact on the productivity of our croplands. This happens in two ways: (i) soil erosion increases manifold, and the soil actually gets washed leading to an accentuated cycles of floods and drought (ii) but equally important is the impact of shortage of firewood on the productivity of our croplands. When firewood becomes scarce, people begin to use cow dung and crop wastes as fuel mainly for cooking. Thus, every part of the plant gets used up gradually and nothing goes back to the soil. Over a period of time, this nutrient drain affected crop productivity due to loss of soil fertility.

I. Major causes of deforestation

The major causes of deforestation are as follows:

1. **Expansion of agriculture:** Expanding agriculture is one of the most important cause of deforestation. As

demand of agricultural products rises and more lands is brought under cultivation for which forests are cleared, grasslands are ploughed and even land under water is reclaimed. During the process of cleaning land, precious timber is simply burnt. Because of this the soil becomes poor in nutrient contents and is unable to support farming for long durations. The barren soil is subjected to massive erosion and degradation.

2. **Extension of cultivation on hill slopes:** The human necessities have forced many to go up to maintain slopes for cultivation. More and more slopes are cleaned of plants and many odd crops are being attempted. After a few crops, the productivity declines and the crop field are left out without cultivation and this leads to soil erosion. This is known as 'Jhoom' cultivation.
3. **Shifting of cultivation:** It is often blamed for the destruction of forests. Indeed, it is the poor fertility of soil which result in such pattern of farming. The crops are grown as long as soil is productive. After which the cultivation is abandoned and cultivators move onto the fresh patch of land. This causes deforestation of fresh areas of forests.
4. **Cattle ranching:** It is also an important factor of deforestation. In many countries, the forests are cleared for the cattle-ranching. The soil degenerates within a short span of time due to the over grazing and massive soil erosion occurs.
5. **Fire wood collection:** The majority of rural population and a large number of people living in small towns and cities of developing countries, the only fuel is wood which is burned to cook food and provides heat during the chilly winter. Fire wood collection contributes much to depletion of tree cover,especially in localities which are lightly wooded. Dense forests produce a lot of combustible material dead twigs, leaves etc.

6. **Timber harvesting:** Timber resource is an important asset for a country's prosperity. Live trees with thick and straight trunks are felled and transported to the commercial establishments elsewhere, to consumers who are ready to pay. In this process, large forest trees are damaged and the system which provide resources gives a tiny share of benefit to the local people. Thus, timber harvesting business also leads to deforestation.

II. Consequences of deforestation

Deforestation involves the removal of plant biomass. Various useful products *viz.*, firewood, timber, honey, fruits, nuts, resins, medicines etc. are no longer available. A chain of events is set up as the consequence of deforestation which are summarized as following:

1. **Degradation of soil and its erosion:** The ground surface becomes barren because of deforestation. In humid tropics, a large proportion of available mineral nutrients is taken away when the biomass is removed. Herbaceous plants and grasses are exposed due to the action of sun, wind and rapidly flowing water. There is further loss of mineral nutrients. Grazing may remove much of the organic matter with which there is further loss of nutrients. Massive soil erosion aggravates flood situation in two ways: (i) the deposition of silt and sediments in river beds makes them shallow, and (ii) land devoid of forest cover looses its water holding capacity.
2. **Climatic conditions:** Forests give shape to the natural environment and local conditions. They maintain humidity, regulate temperature, break wind velocities and influence precipitation.
3. **Humidity:** Active transpiration by green plants keep the environment humid. Roots of trees penetrate

deep down to the sub-surface water table. They are able to draw water even when the surface is dry.

4. **Regulation of atmospheric temperature:** Average air temperature under tree is appreciably lower than those measured in open fields. The type of plants also influences the temperature in a forest.
5. **Wind velocity:** The velocity of wind through a forest is profoundly affected by the density of vegetation. High wind velocities accelerate transpiration and evaporation which in turn speed up dessication. Under drier condition, soil particles become loose and carried away by air currents resulting in a higher rate of soil erosion.
6. **Forest cover and global warming:** A large quantity of carbon is trapped into the forest. The oxidation of this carbon yields a huge quantity of carbon dioxide ($C0_2$) which is added into the atmosphere. This carbon dioxide is used in the process of photosynthesis by the plants. An increase in concentration of this gas in the atmosphere will results into the global warming. About 81.50 billion metric tonnes of carbon dioxide is added into the atmosphere annually. Out of which 70 billion metric tonnes is absorbed by the plants and is converted into the organic matter and remaining 11.5 billion metric tonnes gets dissolved in rain water. Many ecologists believe that deforestation is also contributing to the global warming as it tends to increase carbon dioxide in atmosphere.
7. **Destruction of natural habitats and reduction in biodiversity:** In forests, the trees provide protection, tolerable temperature and adequate humidity etc. to other plants, animals and micro-organisms. Deforestation disturbs and destructs the habitat of a number of species.

8. **Destruction of sink for pollutants:** Forest soils and vegetation have a large capacity to absorb, transform and accumulate various pollutants in the environment. Vegetation acts as an effective sink for the number of undesirable constituents of the environment. Deforestation not only destroys this sink but also reduces the soil capacity to eliminate pollutants.

Moreover, there has been a tendency of establishing forest-based industries without any respect to sustainability of the resource base and that leads to over exploitation. The commercial demand of timber may lead to decimation of forests particularly timber trees.

FOREST FIRES

The forest fire is a major problem which destroys the forests and its biota. This generally happens during the summer season. Forest fire results into the degradation of forests. It effects widely the ecology, economics and also has adverse social impacts.

I. Consequences of forest fires

The forest fires are in existence since the eternal times. The vegetation suffers but is never completely destroyed and is regenerated again. Improved techniques of fire fighting are being used to the control forest fires, but the situation is not changed throughout the ages. The governments have decided to invest the fund for fighting forest fires. The danger of forest fire continues after fire also. The ground soil is washed by the rain water. After a fire, the introduction of burned wood adds numerous mineral materials into the soil.

A fire dramatically makes impact on the animals. Insects loose their lives due to heat and smoke, and their

eggs are also destroyed by the fire. Birds migrate due to fire and animals moves here and there. Thus, there is a loss of biodiversity of the forests. Forest fires spread rapidly in big areas and animals come into the contact of fire, burnt and die. Trees sweat as human beings and introduce moisture to the air, when it is hot. If the trees are missing after a fire, the climate becomes drier and this in turn is conducive for another fires. If two mountain ridges are burning, this does not change the climate of an area. So the forest fires have clearly predictable influence on the climate of an area. Thus, the impacts of forest fire are: loss of timber resources, depletion of carbon sink, degradation of water catchment areas, loss of biodiversity, extinction of plants and animals, destruction of wildlife habitats, global warming, soil erosion, ozone layer depletion, and indirect effect on agriculture production.

II. Control measure of forest fires

The forest fire can be controlled in the following ways:

1. **Through public awareness:** It includes cultured activities, forest fire control activities, engineering works, people's participation, education and enforcement.
2. **Remote sensing technology:** For the control of forest fires, the remote sensing technology can be used. For the successful fire management and administration, a National Fire Danger Rating System and Fire Forecasting System be developed in the country.
3. **Fast initial attack measures:** These should be taken for the forest fire control.
4. **Vigorous follow up action:** It can control forest fire.
5. **Control on forest firing:** This may also prevent the forest fire.

ENERGY RESOURCES

Energy is an important input for the development. Ecologist and economist have looked at energy from different point of view. For ecologists, the study of energy begins with sunlight, considering first its conversion by the green plants into the chemical energy of the organic compounds and then the transfer of this energy through food chains to the animals and human populations. For economists, the study of energy has involved the immediate sources of energy of human needs. It aims at human welfare covering household, agriculture, transport and industrial complexes. Like other natural resources, energy resources are also of two types *viz.*, renewable and non-renewable resources. The term resources is a mean for satisfying human and social requirements.

1. **Renewable (Inexhaustible) energy resources:** The resources which can be re-newed over relatively in short duration are referred as renewable energy resources. These are mostly biomass based and are available in good amount in nature. These include firewood, which obtained from forests, petro-plants, plant biomass, cattle dung, solar energy, wind energy, water energy (hydro-electric and tidal energy), geo-thermal and dentro-thermal energy etc. These resources can be harvested continuously through a proper planing and sustained management.
2. **Non-renewable (Exhaustible) energy resources:** The non-renewable energy resources are those which are available in limited amount and develop over a longer duration. Because of unlimited use, they are likely to be exhausted some day. The non-renewable energy resources are coal, mineral oil, natural gas and nuclear power. Coal, petroleum and natural gas are commonly used sources of energy. They are also referred as fossil fuels.

The energy resources can also be categorized as conventional and non-conventional energy resources.

I. Conventional energy resources

The expansion of possible energy sources has been directly related to the place of industrial and agricultural development in almost every part of the world. With vast expansion of industry and agriculture sectors, the available energy sources begin to fall in their supply.

The fire wood is used as fuel for domestic purpose, mainly in rural areas. Coal is in already use in many industries. It was then supplemented by mineral oil. Likwise, the use of hydroelectricity (water energy) is also a source of energy. After the second world war (1945), nuclear power was developed as a source of energy. All these sources of energy are known as conventional sources of energy, among which the coal occupies a central position. In short, major sources of energy in this category are coal, mineral oil and natural gas, firewood and nuclear power. All these conventional energy sources are discussed as follows:

1. **Coal:** It is a major source of industrial energy and is also used as a raw material. Coal including lignite even today accounts for 60% of the country's commercial requirement. Major coal fields in India are Raniganj, East and West Bokaro, Pench-Kanhan (Tawa) valley, Chanda-Wardha valley and Godavari valley. Maharashtra, Madhya Pradesh, Orissa, Bihar and West Bengal are the major states of India which are known for their coal mines. About 6,000 billion tonnes of coal lies under the earth and by now above 250 billion tonnes has been used. During 1986, the total coal production was 3230 million metric tonnes and upto 2007 it may reach around 7,000 million metric tonnes. It was observed that the quality of

Indian coal is rather poor in heat capacity. This poor heat capacity can be converted into the electricity, gas and even oil. That's why the thermal and super thermal power plants are located on the coal fields to produce electric power to feed regional grids.

2. **Mineral oil and natural gas:** The sedimentary rocks are the source of mineral oil. The mineral oils are unevenly distributed over the space like any other mineral. There are six regions in the world which are rich in mineral oil production. The USA, the USSR then Mexico and West Asia (Saudi Arabia, United Arab Emirates, Qatar, Bahrain, Iran and Iraq) are the major oil producing countries in the world. In India, Bombay High (Mumbai coast), 115 km from the shore is the richest oil field of the country. The latest oil deposits have been found in off shore areas off the deltaic coast of Godavari, Krishna, Cauveri and Mahanadi. The gas reserve are generally found in association with oil fields. In India, the gas reserves are located in Tripura, off shore fields of Gujarat, Maharashtra, Tamilnadu, Andhra Pradesh and Orissa. In India, natural gas is a gift of nature. It can be used both as energy source and also an industrial raw material in the petro-chemical industry. The natural gas is also used in fertilizer plants. There are 12 refineries in India. Liquified Petroleum Gas (LPG) is used as cooking gas and is a common domestic fuel in the country.
3. **Thermal power:** The thermal power plants use coal, petroleum and natural gas to produce thermal electricity. Electricity is the most convenient and versatile form of energy. It is in great demand in industries, agriculture and domestic sectors. Both the big and small power stations are scattered all over the country. Electricity produced by them is fed into regional grids. There is now a single National

Grid. The grid receives electricity produced from all the four major sources *viz.*, coal, oil, water and nuclear. The total length of lines was 10,000 circuit km in 1950. Now, it increased to more than 200 fold. Besides these, there are high voltage transmission lines of 400 kv strength (16,000 km) and 220 kv strength (55,855 km).

4. **Fire-wood:** The fire wood is also a major conventional source of energy. It is estimated that around 70% fire wood demand pertains to the rural areas. Only 50 metric tonnes fire-wood become available from the forests. To solve the problem of fire wood, new technologies have been developed. These are briquetting (briquetting saw dust into smokeless fuel), gasification, improved *chullahs*, improved stoves. Beside these, coal cakes, cow dung, pellets etc. are also used as source of energy.
5. **Hydro-power:** Water energy is most conventional renewable source of energy. Energy is obtained from flow of water or water falling from a height. Hilly and highland areas are suitable for this purpose. Technology was also developed for the use of stream energy. Hydropower is a clean, non-polluting source of energy. It can be transmitted through wires and cables. But this form of energy can not be stored for future. Thus, the market are to be fixed before generation of hydro-power energy. In South America 75% of the total electricity consumed is from the hydropower plants. Japan, fore runner USSR and then USA are the major countries involved in the production of hydropower. In India, this situation is different. Many dam projects on the rivers are completed but the production of hydro-power is limited to selected dams only. This is due to some technical problems.
6. **Nuclear power:** Nuclear power is a principal source of energy, when the fuel resources are depleting very

fast. A small quantity of radioactive material can produce an enormous amount of energy. For example one tonne of Uranium^{235} can produce as much energy as by three million tonnes of coal or 12 million barrels of oil.

The nuclear (atomic) power is also used as a fuel for marine vessels, heat generation for chemical and food processing plants and also for space-crafts. For the production of atomic energy, require a nuclear reactor is required. The energy is produced by the fission of atoms. There are different types of nuclear reactors *viz.*, (a) Light Water Reactor, (b) Heavy Water Reactor and (c) Liquid Metal Fast Breeder Reactor.

(a) **Light Water Reactor:** In this ordinary water is used for cooling and moderation. These are also sub-divided into boiling water reactor and pressurized water reactor.

(b) **Heavy Water Reactor:** Here heavy water, deuterium oxide is used for cooling and moderation.

(c) **Liquid Metal Fast Breeder Reactor:** In this type of reactor, the liquid sodium is used as coolant.

The atomic power plant are located in the USA (83), US (40), UK (35), France (34), Japan (25), Germany (15) and Canada (13). Thus, there are around 300 atomic plants in the world. In India, at present there are 6 nuclear power plants. One each is in Maharashtra (Tarapur), Rajasthan (Kota), Tamilnadu (Kalpakam). Remaining units have come up in Gujarat (Kakarapar), Karnataka (near Karwar) and Uttar Pradesh (Narora). India has been a leader in making peaceful use of nuclear power in medicine, agriculture and space. In India, Nuclear Power Corporation is engaged in the establishment of nuclear power plants.

II. Non-conventional energy sources

The countries around the world have started thinking about a policy on energy and look into a possibility of having energy

systems with no or very limited conventional energy sources. The energy crisis during 1970s forced scientists to develop alternative sources of energy that should be renewable and pollution free. Due to the rapid depletion of conventional energy sources, the countries all over the world have been concentrating over the non-conventional energy sources. In India, Department of Non-conventional Energy Resources is actively engaged in research and development activities for evolving the non-conventional energy resource technology. The major non-conventional energy resources are solar energy, wind energy, ocean (tidal) energy and geothermal energy. Biomass based energy which includes petroplants, biogas, dendro-thermal energy (energy plantation), energy from urban waste and biogas based plants also come under this category. The non-conventional energy resources are as follows:

1. **Solar energy:** This energy is one of the most important non-conventional energy resource. Domestic heating and water supply can be met by this resource. In Israel, such systems of heating homes and water supply are already in operation. In U.S.A. commercial solar heaters are available in Florida and California. In Asia, Africa and Australia, there is bright sunshine during day time, the solar energy has promising future. India receives abundant sunshine about 1,648 to 2,108 KWh m^2 yr^1 with nearly 250-300 days of useful sun shine in a year. Daily solar energy store is 5 to 7 KWh m^2 yr^1 at different parts of the country. This enormous solar energy resource may be converted into the other forms of energy through the thermal conversion. The solar thermal route uses radiations as heat that may be converted into electrical or mechanical energy. There are solar thermal devices for storing solar energy. They are solar cookers, solar water heaters, solar dryers etc. Solar cookers consist of aluminium

reflector. Indian Institute of Technology, Kharagpur have achieved success in developing the technology to trap solar energy in remote areas of Leh and Ladakh. It was observed that in solar cookers one meter square collector area has 17.3% efficiency which saves 663 kg of wood that produces 4708 x 10^3 Kcal kg energy.

The photovoltaic conversion system converts solar radiation directly into electricity through silicon solar cells. These may be single crystal silicon cells, polycrystaline cells, amorphic solar cells etc. The electricity produced from solar cells can be used for community lighting, radio and TV sets, light houses etc. The systems are totally free from chemical and noise pollution. These systems may be installed in remote areas like forests, deserts etc. The Rural Electrification Corporation has identified around 1 lakh villages in the remote areas where electrification is costly and physically tedious. In such areas, photovoltaic systems can be used alongwith biomass based systems. More than 100 domestic solar heaters of 100 litres capacity are installed in different parts of Haryana. A photovoltaic irrigation pump set has been installed at Haryana Agriculture University, Hisar (Haryana).

2. **Wind energy:** This energy is second important non-conventional energy resource. In this resource, the wind energy is being converted into mechanical and electrical energies. Today, wind energy has been utilized for pumping water in rural and remote areas. It was estimated that about 20,000 mW electricity can be generated in India from wind. There are many wind mills for the production of wind energy. The wind energy can also be used in remote areas. It also helps in saving fossil fuels. Gujarat is the first state in India which started using wind power for various purpose.

3. **Tidal energy or ocean energy:** The most important application of tidal power is the electricity generation. This tidal energy is obtained from the tides. The tides may be high and low. The tidal power generation depends on the harnessing of rise and fall of sea level due to tidal action. Small tidal power plants have been constructed in China and USA. In India, prospective sites for exploitation of tidal power plants are Gulf of Kutch, Cambay and Sundarbans.

   In India, tidal power potential of 9,000 mW has been identified. Of which 800-1000 mW exists in Gulf of Kutch, 7000-8000 mW in Cambay and rest in Sundarbans area. India could intensify work on Ocean Thermal Energy Conversion (OTEC) and wave energy. India has an excellent OTEC potential. Total OTEC potential around India to nearly 50,000 mW which is nearly 150% of the total installed power generating capacity in the country today.

   The tidal energy can be divided under the two categories: (i) Ocean Thermal Energy Conversion, and (ii) Wave energy.

   A. **Ocean Thermal Energy Conversion:** A floating OTEC plant can generate power even at mid-sea and can be used to provide power for operations like off-shore mining and processing of mining nodules. There is a proposed plan for OTEC in Lakshadeep island.

   B. **Wave energy:** The incessant motion of the sea surface that forms of wind wave which constitutes the source of energy. About 1.5% of the incoming energy from the sun is converted into the wind energy. Some part of this energy is transferred to the sea surface resulting in the generation of waves. These waves are then carried to the coastal lines where they are dissipated as the wave break. India has coastal

line of approximately 6,000 km and it has a potential of generating around 60,000 mW. Gujarat may become the first state in the country to make use of tidal power.

4. **Geothermal energy:** The geothermal energy is the energy or heat produced in the interior part of the earth. This energy is utilized for power generation. Such power generation plants are possible only in the volcanic regions, places of hot spring and at the occurrence of geysers. This geothermal energy can be used for generating power and creating refrigeration etc. At present 400 geothermal springs are in the country. Puga (Ladakh) is one of the major geothermal area for power generation. Other areas to be screened are Tattapani (Sarguja District, Chhattisgarh), Cambay basin (Maharashtra) Alaknanda valley (Uttar Pradesh) and Parvati valley (Himachal Pradesh).
5. **Biomass based energy:** Biomass is the material originating from the photosynthesis. It includes plants residues, wastes, biodegradable organic effluents from industries etc. From the biomass, we can produce biomass energy. There are systems referred biomass energy systems which produce energy. These systems are renewable. The biomass based energy can be produced from petro-plants, biogas, energy plantation, urban waste, sugar-mill waste etc.
    1. **Petroplants:** There are about 385 species of petro-plants. Out of these,15 species are promising. The petroplants belongs to families Euphorbiaceae, Asclepiadaceae, Apocynaceae, Urticaceae, Convolvulaceae and Sapotacae. These petro-plants posses high hydrocarbons contents. These contents can be converted into the petroleum. The Indian Institute of Petroleum, Dehradoon has done

excellent work in this area, particularly on hydrocracking of the crude products.

2. **Biogas:** This is an important solution to present energy crisis, especially to the rural areas. This is an environmentally clean technology. Successful experiments on the biogas of cattle dung and dry plant waste have been conducted. It is estimated that 1,50,000 plants will save 6,00000 tonnes of wood per year.

   In biogas technology, two things are important: (i) Restricted use of water and (ii) Better strains of methane gas (CH_4) producing bacteria. For normal microbial activity 90% water is required. Biogas can also be produced from raw sewage slurry. Such plants are established at Okhala (Delhi). Besides gas from raw sewage, it can be used as a good manure. Una Grams have been developed which produce biogas by using biomass, poultry waste and human excreta.

3. **Dendrothermal energy (Energy plantation):** Wasteland can be used for plantation of fast growing shurbs and trees with their specific value. They in turn provide fuel wood, charcoal, fodder, power and also have a good scope for rural employment. The method of generating energy from energy plantation has been experimented particularly in the Philippines. In India, such plantations are being planned to set up in Rajasthan and Madhya Pradesh on experimental basis.

4. **Energy from wastes:** A pilot plant for demonstration has been already set up in New Delhi to treat municipal waste for the conversion of energy. Sewage in cities is used for generating gas and electricity.

5. **Sugar mills wastes:** The sugar mill waste called bagasse can be used to generate energy. About 2,000 mW electricity can be produced from bagasse. Like bagasse, other farm wastes as rice husk can also be used to produce electricity.

QUESTIONS

Natural resources

1. Give an account of the natural resources and their conservation.
2. Define the conservation. What are the conservation measures of freshwater resources?
3. Explain the term deforestation.What are the major causes of deforestation?
4. Give an account of the consequences of deforestation.
5. Write short notes on:
   (i) Forest fire,
   (ii) Deforestation

Energy resources

1. Give an account of the non-conventional energy resources.
2. Describe the conventional energy resources.
3. Write short notes on:
   A. Geothermal energy
   B. Tidal energy
   C. Biogas
   D. Petroplants
   E. Wind energy

20

WILDLIFE CONSERVATION

The wildlife is a gift of nature which helps to embellish the natural beauty by their unique way of existence. Due to growing deforestation and negligence, there is a threat to the wildlife. It will require special attention to save the world from loosing its green heritage. Some of the government initiatives carried out to preserve this natural heritage include the Project Tiger. This is one of the most successful efforts made in preserving and protecting the tiger population. Gir National Park in Gujarat is the only existing habitat for the Asiatic lions in India. The Kaziranga sanctuary in Assam is a prime example of an effort to save the endangered Rhinoceros. Likewise, Periyar National Park in Kerala is doing appreciable work to preserve the wild elephants while Dachigam National Park is working hard to save the Hangul or Kashmir Stag. Thus, the nature projects and programmes started by the Government of India like the Project tiger, nature camps and jungle lodges have been started to promote wildlife awareness among the common man. The project besides preserving our natural heritage, also encourages eco-tourism.

The term 'wildlife conservation' is defined as to conserve the wild species of plants and animals which are on the way of extinction and utilize them for the benefit of mankind. Wildlife conservation is a broad term. For the

conservation of wildlife, the Government has established national parks and sanctuaries and also started Biosphere reserve programmes along with the project Tiger. There are also various Non-Governmental Organizations working on wild life conservation in India such as Wildlife Society of Orissa (Orissa), Rhino Foundation for Nature (Assam), Friends of Forests (Maharashtra), North-Eastern Society for Preservation of Nature and Wildlife (West Bengal), Nature's Beckon (Assam), Nature Conservation Society, Amravati (Maharashtra). The Friends of the Doon (Uttaranchal) and Bale Nature and Wildlife Conservation Society (West Begal) etc.

BASIC CONCEPT OF WILD LIFE CONSERVATION

For the conservation of wildlife, the International Union of Conservation of Nature and Natural Resources (IUCN) has categorized the rare species of plants and animals in four categories. The classification is based on the present and past distribution of species, the abundance and quality of natural habitat, the decline in the density of population in time, and the biology and ecological values of species.

On this basis, the classified categories are: endangered species, vulnerable species, rare species, and threatened species.

1. **Endangered species:** The endangered species are those which are under the danger of extinction and may not survive, if the adverse factors continue to operate.
2. **Vulnerable species:** The vulnerable species are those species whose population has been seriously decreased and also their security is not assured.
3. **Rare species:** The rare species are those species which are remaining in small proportion in the world.

Such species are usually found within the restricted geographical areas or habitats.

4. **Threatened species:** The threatened species are those which are under the threat of extinction.

CAUSES OF WILDLIFE DESTRUCTION

There are many causes of wildlife destruction. Some of the important causes are: destruction of wild life animal habitats, due to deforestation for various purpose, natural calamities such as floods, fires etc. reduce the wild life, Hunting of wild life animals also causes loss of the wild life. Because of all these reasons, the wildlife is reduced seriously so that it becomes necessary to conserve it.

MODES OF WILD LIFE CONSERVATION

There are various modes for the conservation of wild life, such as: protection by law, declaring protected species of wild life, and establishment of national parks and sanctuaries.

1. Protection by laws

The Government of India had passed the Wildlife Protection Act in 1972. According to this act, possession, trapping, shooting of wild animals, alive or dead, serving their meat in meals, their transport and export etc. are all controlled under the wildlife conservation authorities. This act also prohibits the hunting of female and young ones. Under this act, threatened species are absolutely protected and the rest are afforded with graded protection.

2. Protected species of wildlife

There are many species of wild animals and plants. Some of the important protected wild animals are swamp deer, Chinkara or Indian gazelle, musk deer, Indian antelope or black buck, 4-horned antelope, pea fowl, pheasant, ducks, python, ghariyal, crocodile, turtles etc.

3. Establishment of National Parks and Sanctuaries

Wildlife is to be protected by establishing the National Parks and Sanctuaries. Creation of biosphere reserve has also been put into practice since 1986. In India, there are 96 national parks covering an area of 38,029.18 km^2. There is a plan to establish 166 national parks in the different states of India.

Sanctuaries are the places where the killing or capturing of any animal is prohibited. Sanctuaries provide protection and optimum living conditions to the wild animals. In India, around 400 sanctuaries are existing today.

Beside national parks and sanctuaries, biosphere reserves have been evolved under the Man and Biosphere programme of the UNESCO. In India, 13 areas are declared as Biosphere reserves including Nilgiri biosphere reserve in Karnataka, Nanda Devi biosphere reserve in Tamilnadu, Valley of flowers in North-Himalaya, Uttarakhand, North-Himalaya Biosphere Reserve, Nokrek etc.

The Government of India had also started projects on Tigers Conservation under the title 'Project Tiger'. Under this project, many tigers are protected. Other projects include Gir Lion Project, Elephant Project, Crocodile Project, Rhino Conservation Project etc.

OTHER MEASURES OF WILD LIFE CONSERVATION

Other measures of wild life conservation are: natural habitats of wild animals should be carefully protected, habitats of wild animals must be improved including water holes, saltlicks, plantation around them for shelter etc.

Estimations of annual population of wild animals, complete ban on hunting, public awareness about wildlife conservation by taking different programmes created, and veterinary treatments to the wild animals etc. should also be taken up.

Importance of wildlife conservation

Due to the growing impact of deforestation, continuous efforts are being made by some anxious animal lovers to protect the endangered species of wildlife as well as those that are on the verge of extinction and thus save the world from running out its green heritage. Wildlife is important due to the following reasons:

1. **Beauty:** By their unique way of existence, wild creatures exaggerate the natural beauty of the earth.
2. **Economic value:** The financial value of wild species is important to economics of several nations, as it provides many valuable substances like wood and other plant products, fibers, meat and other foods, skin and furs.
3. **Scientific value:** By studying the wildlife, scientists have gained valuable knowledge about various life processes and discovered important medicinal products.
4. **Survival value:** Wildlife helps in maintaining the balanced living systems of earth, which consequently ensures survival of life.
5. **Tourism:** Wildlife enhances the tourism business. Many people visit to national parks and sanctuaries and enjoy the natural beauty and wild life.
6. **Cultural asset:** The wildlife of India is our cultural asset and has deep-rooted effect on Indian art, sculpture, literature and religion.
7. **Sports and recreation:** The wildlife provides best means of sports and recreation etc.

QUESTIONS

1. Write an essay on wildlife conservation in India.
2. What is the basic concept of wildlife conservation?
3. Explain causes of wildlife destruction and also different modes of wild life conservation.
4. What is the importance of wildlife conservation?
5. Write notes on:
   A. Wildlife conservation
   B. Modes of wildlife conservation
   C. Importance of wildlife conservation

21

ENVIRONMENTAL BIOTECHNOLOGY

Today's age is age of science. A number of experiments are being conducted by the scientists throughout the world. The scientific experiments are continued for a long period to develop technology. These technologies are used for the benefit of mankind. Environmental biotechnology is also such an important field. The environmental biotechnology employs the application of genetic engineering to improve the efficiency and cost which are central to the future widely spread exploitation of micro-organisms to reduce the toxic substances in the environment. It is hoped that in future, the application of micro-organisms along with genetic engineering will make a major contribution to improve the quality of our environment. However, there is risk of releasing genetically engineered micro-organisms into the environment. The use of micro-organisms for cleaning the environment and with special reference to bioremediation, biofertilizers, vermiculture, vermicomposting, vermiwash and terminator seed technology are disscussed here.

Pollution of air, water and soil is expanding day by day due to the rapid increase in the world population. About millions of people are added into the world population every year and therefore, more and, more industries, food,

medicine, motar vehicles etc. are required for fulfilling the need of people. These can be only possible by the help of technology and biotechnology. However, the modern biotechnologies are based on the genetic engineering that may solve all these problems of pollution arising due to industrial technologies.

BIOREMEDIATION

Bioremediation means the use of living micro-organisms for degrading the pollutants in the environment or to prevent the pollution. Bioremediation is a technology which is used for removing the pollutants from environment, restoring the contaminated sites and also used for prevention of future pollution. The base of bioremediation is micro-organisms which degrades the organic compounds. This capacity could be improved by applying the genentically engineered micro-organisms. India, Japan, U.S.A. etc. are doing research on environmental biotechnology. The work is carried out to develop the biopolymers which retain water and reverse desert formation. *Alcaligens luteus* is being used to produce super biosorbents which are composed of glucose and glutonic acid. Its water absorbing capacity is more than thousand times of its own weight. Bioremediation technology has been used for removing the environmentally hazardous chemicals accumulated in the cells. Many species of algae, fungi and bacteria are known to solubilize, transport and deposit the metals, detoxify dyes and complex chemical compounds. The toxic waste material remains in vapour, liquid or in solid state. So,the bioremediation technology is varying accordingly depending upon whether the waste material is removed in its natural setting or is removed and transported into a fermentor (bioreactor). On this basis for removal and transportation of waste for the treatment, there are two major types of bioremediation. These *are:In-situ* bioremediation and *Ex-situ* bioremediation.

In situ bioremediation

In situ bioremediation involves direct contact between micro-organisms and the dissolved contaminants for the biotransformation. The potential advantages of *in situ* bioremediation methods include minimal site disruption, simultaneous treament of contaminated soil and ground water, minimal exposure of public and site personnels and low cost. Disadvantage of *in situ* bioremediation are:

(i) It is a time consuming method as compared to other remedial methods.

(ii) Seasonal variation of microbial activity resulting from direct exposure to prevailing environmental factors and lack of control over these factors cause delay in the process.

(iii) Application of treatment additives (nutrients, surfactants and oxygen) cause problems.

The micro-organisms act well only when the waste material help them to generate energy and nutrient to build up more cells. When the native micro-organisms have been lacking biodegradation capacity then genetically engineered micro-organisms (GEMS) may be added during *in situ* bioremediation. Basically, there are two types of *in situ* bioremediations. These are: intrinsic *insitu* bioremediation and engineered *in situ* bioremediation.

A. Intrinsic *in situ* bioremediation

The conversion of environmental pollutants into the harmless forms through the innate capabilities of naturally occurring microbial population is called intrinsic *in situ* bioremediation. Intrinsic means inherent capacity of micro-organisms to metabolize the contaminants should be tested in the laboratory and field levels before their use for intrinsic bioremediation. The sites which favour intrinsic biremediation are groundwater flow throughout the year, carbonate minerals to buffer acidity produced during

bioremediation, supply of electron acceptors and nutrients for the microbial growth and absence of toxic compounds. The other environmental factors are pH and temperature. Whether or not biotransformation takes place, the bioremediation of waste mixtures containing metals *viz.*, mercury, lead, arsenic and cyanide at toxic concentration may create some problems in bioremediation.

B. Engineered *in situ* bioremediation

When the site conditions are not suitable, the bioremediation requires construction of engineered systems to supply materials which stimulate the micro-ogranisms. Engineered *in situ* bioremediation accelerates the desired biodegradation reactions by encouraging growth of micro-organisms via optimizing physico-chemical conditions.Oxygen and electron acceptors (*e.g.*, $N0_3^{1}$~ and $S0_4^{2}$~) and nutrients *e.g.*, nitrogen and phosphorus) promote microbial growth on the surface. In case contamination is deeper then amended water is injected through wells.

Ex situ bioremediation

Ex situ bioremediation involves the removal of waste materials and their collection at a place to facilitate microbial degradation. *Ex-situ* bioremediation technology has many disadvantages and limitations. It is an expensive technology. It suffers from cost associated with solid handling process like excavation, screening and fractionation, mixing, homogenizing and final disposal. *Ex situ* bioremediation is classified into two types *viz.*, (i) solid phase system and (ii) slurry phase system.

I. Solid phase system

It includs land treatment and soil piles. In this system, the organic wastes (*e.g.*, leaves, animals manures and

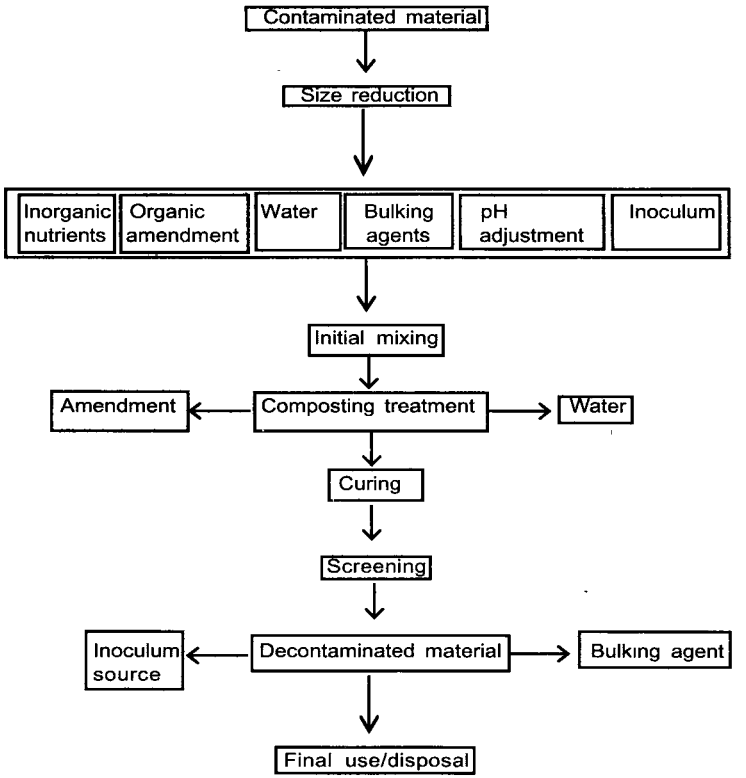


Fig. 21.1. Composting Treatment

agriculture wastes) and problematic wastes (*e.g.*, domestic and industrial wastes, sewage sludge and municipal solid waste) are used. The traditional clean up practices involve the informal processing of organic materials and production of compost which may be used as soil amendment.

Composting is a self heating, substrate dense and managed microbial system. As composting is a solid phase biological treatment, target compounds must be either solid or liquid associated with a solid matrix. The hazardous compounds should be biologically transformed. For achieving this goal, the waste material should be suitably prepared so that the biological treatment potential should

maximize. This is possible by the adjustment of several physical, chemical and biological factors. The hazardous waste must be well solubilized so that they may be available and used. These hazardous compounds and soil organic matter serve as the source of carbon and energy for micro-organisms. Microbial enzymes are secreted during the growth phase which degrade the toxic compounds. However, the proper maintenance of water, oxygen, inorganic nutrients and pH increase the rate of decomposition. The outline of composting treatment sequence is given in Fig. 21.1. To provide experimental proof of biodegradation during pesticide, sludge-wood chip ^{14}C-labelled carbaryl was added in the sewage composting, a common hazardous contaminant mixture at 1.3 to 2.2 ppm. After 15-20 days in the laboratory composting apparatus, 1.6 to 4.9% of carbaryl was recovered as $^{14}CO_2$ and remaining pesticide was found bound to the soil organic matter.

II. Slurry phase system

This system involves the treatment of solid-liquid suspension in bioreactors. It is a triphasic system in which three major components are used *i.e.*, water, suspended particulate matter and air. Here, the particulate matter includes a biologically inert substratum which consists of contaminants (soil particles) and biomass attach to the soil matrix or free in suspending medium. Air provides oxygen for the bacterial growth. The slurry phase reactors are used for the treatment and in market they are available in various designs. Biologically there are three types of slurry phase bioreactors: (a) aerated lagoons, (b) low gear airlift reactor and (c) fluidized-bed soil reactor. The first two types are in use of full-scale bioremediation, whereas third one is in developmental stage. Factors which affects the slurry phase biodegradation are pH (5.5 to 8.5), temperature (20° to 30 °C, oxygen (aerobic medium), aging, nutrient contents

(N,P and micro-nutrients), microbial population, moisture content etc.

III. Bioremediation of different polluting sources

Bioremediaton of different pollutants is discussed as under:

1. **Bioremediation of hydrocarbons:** Petroleum and its products are hydrocarbons. These two have very high economic importance. Oils constitutes a variety of hydrocarbons *e.g.*, xylenes, naphthalenes, octanes, camphor etc. If these hydrocarbons are remaining present in the environment, they may cause pollution. During cold war between Iraq and U.S., millions of gallons of petroleum was leaked into the sea which resulted into the heavy fish mortality. Besides this, oil and petrol leakage in the marine environment is a common phenomenon. In toxic environment, micro-organisms act only when the conditions like temperature, pH and inorganic nutrients are optimum. Oil is insoluble in water and it floats on the surface of water and form slacks. The micro-organisms which degrades petroleum are *Pseudomonas* sp., cyanobacteria, mycobacteria and some yeasts. There are two methods for the bioremediation of hydrocarbons / oil spills *viz.*, (i) by using the mixture of bacteria, and (ii) by using genetically engineered microbial strains.
   A. **Use of mixture of bacteria:** A large number of bacteria are present in the water and oil droplets. Each strain of bacteria consumes a very limited amount of hydrocarbons. Thus, the mixture of bacteria has successfully been used to control oil pollution. Bacteria which are living in the interface degrade the oil at slow rate. The rate of degradation is accelerated with human intervention. Artificial mixture of bacterial strain is applied to oil spill areas, it will increase the rate of bioremediation significantly.

B. **Use of genetically engineered bacterial strains:** In1979, Anand Mohan Chakrabarty, an India born American scientist, found out a strain of *Pseudomonas putida* which contained the XYL and NAH plasmid as well as a hybrid plasmid derived by recombining the parts of CAM and OCT.

These strains grow rapidly on crude oil as it is capable for metabolising the hydrocarbons more efficiently than any other single plasmid. In 1990, the U.S. Government allowed to use this superbug for cleaning up of an oil spill in waters of Texas. Superbug was produced on a large scale in the laboratory, mixed with straw and dried husk. The bacteria laden straw can be stored until required. When the straw was spread over the oil slakes, the straw soaked up the oil and bacteria broke up the oil into non-polluting and harmless products.

2. **Bioremediation of industrial wastes:** A large number of types of pollutants are discharged into the environment from industries and mills, *e.g.*, textile industry releases enzymes, acids, alkalies, alcohols, phenols, dyes, heavy metals etc. in the water. Trace metals like zinc, cadmium, mercury, copper, chromium and lead etc. are found in dyes. The Actinomycetes show a higher capacity to bind metal ions as compared to other fungi and bacteria. The living microbial cells accumulate metals intracellularly at a higher concentration, whereas dead cells precipitate metals in and around cell wall by several metabolic processes. Dead biomass immobilised on polymeric membrane absorbs uranium well, and immobilized *Aspergillus oryzae* cells on reticulated foam particles have been used for cadmium removal.

3. **Bioremediation of dyes:** There are only limited studies on microbial degradationof azo and reactive dyes. Maximum number of dyes undergo degradation through reduction. Kulla (1981) observed that azo-reductase of *Pseudomonas* strain are present in the chemostat culture. This enzyme catalyses azo-linkage of the dye. During degradation process of azo dyes, NADP act as an electron donor. A bacterial strain, *Pseudomonas putida* degrades the black liquor pulp mill effluents also. Similarly, some anaerobic bacteria and fungi decolourise the chromogenic dyes.
4. **Bioremediation of heavy metals:** Bacteria,algae, fungi, actinomycetes and higher plants accumulate high amount of heavy metals in their cells.
5. **Bioremediation of coal wastes:** In recent years, the bioremediation of coal waste has been done through the VAM fungi and this has become of increasing importance. In this method, selected VAM fungi are introduced through plants in coal mine areas. Extensive infection of most plant species colonizing on coal waste has been observed in India and other countries. It has been found that VAM fungi improved the growth and survival of desirable revegetation species. The increasesd growth of maize, maple and several other plants inoculated with VAM fungi grow well in coal mine soil.
6. **Bioremediation of pesticides:** Today, many pesticides are used for improving the quantity and quality of food grains. Use of pesticides has becoming an integral part of the modern agriculture system. Many compounds like xenobiotics persist in the environment and do not undergo biological transformation. Micro-organisms play a very important role in the degradation of xenobiotics and

maintaining the steady state concentration of chemicals in the environment. The complete degradation of a pesticide molecules to its inorganic components that can be eventually used in an oxidative cycle and removes its potential toxicity from the environment. However, there are two objectives in relation to biodegradation of xenobiotics: (A) How the biodegradation activity arises, evolves and transferred among the members of soil microflora ? and (B) To device bioremediation methods for removing or detoxifying higher concentration of dangerous pesticide residues. The pesticide degrading characteristics of micro-organisms located in plasmids and transposons and are grouped in clusters on the chromosomes.

Day by day, the number of xenobiotic degrading micro-organisms are increasing. However, pesticide degarding genes of only few micro-organisms have been characterized. Most of the genes are responsible for the catabolic degradation located on the chromosomes, but in few cases, these genes are found on plasmid or transposons. Researchers have found that camphor degrading genes of *P. putida* are located in the plasmid. After this, naphthalene (NAH) degrading plasmid was isolated. The discovery of these genes made it possible to construct a new genetically engineered strains of *P. putida* which have potential to degrade camphor, naphthalene, xylene, toluene, hexanes and octanes. In 1990, Sims and associates transferred a recombinant DNA plasmid containing opd gene in a fungus, *G. virens* which expressed at low level. *G. virens* is a useful soil saprophyte with proven mycoparasitic activity against many fungal pathgens. Strains of *G. virens* are potential tool for the use in bioremediation of contaminated soil. Optimization of opd expression (opd gene) is bioremedically useful organism *viz.*, *P. chrysosporium,*

G. virens etc. hold a great promise in reducing the pesticide pollution.

BIOFERTILIZERS

The use of chemical fertilizers and pesticides has caused tremendous harm to the crop lands. Answer to this environmental problem is use of biofertilizers which are eco-friendly and are now used in several countries of the world. The term 'biofertilizers' denotes all the nutrient inputs of biological origin used for plant growth. Biological origin means the microbiologial process synthesizing complex compounds and further release into outer medium to the close vicinity of plant roots which are in turn taken up by the plants. Therefore, the appropriate term for biofertilizers is 'microbial inoculants'. In other words, the biofertilizers are the fertilizers produced by the activity of the micro-organisms like bacteria, fungi and algae which enrich the nutrient quality of soil. In recent years, use of microbial inoculants as a source of biofertilizers has become a hope for most of the countries from environmental as well as economic point of view. Biologically fixed nitrogen is a source which supplies an adequate amount of nitrogen to the plants and other nutrients to some extent. It is a non-hazardous way of fertilization of fields. Moreover, biologically fixed nitrogen consumes about 25 to 30 % less energy than normally done by chemical process. Therefore, the developing countries including India can solve the problem of high cost of fertilizers and thus help the country's economy by using biofertilizers. As bacteria and cynobacteria are known to fix the atmospheric nitrogen, both of them are widely used as biofertilizers.

1. Bacteria

Many free living and symbiotic bacteria fix atmospheric nitrogen. Therefore, certain measures are adapted to

increase the number of such bacteria in soil which may increase the gross yield of nitrogen. Two methods *viz.*, bacterization and green manuring are the most widely used techniques.

A. **Bacterization:** It is a technique of seed dressing with bacteria like *Azotobacter, Bacillus, Rhizobium* etc. It has been proved that bacteria can successfully be established in root region of plants which in turn improve the growth of the hosts. Bacterial fertilizers named 'Azotobacterin' (containing cells of *Azotobacter chroococcum*) and 'Phosphobacteria' (containing cells of *Bacillus megaterium* and *Phospharicum)* have been used in many countries like the U.S.S.R. and East European countries respectively. These fertilizers increased the crop yield upto about 10 to 20%. Subsequently bacterization of seeds in Russia, Poland, Bulgaria, Hungary, England and India has clearly demonstrated the increase in crop yield such as wheat, barley, maize, sugarbeet, carrot, cabbage and potato. Rhizosphere bacteria secrete growth substance and antibiotic secondary metabolites which contribute to seed germination and plant growth. Moreover, in recent years, free living *Azotobacter,* associated *(Azospirillum)* and symbiotic *(Rhizobium)* and phosphate solubilizing bacteria are gaining popularity. These practices are also gaining popularity. These practices are being encouraged to cut down the use of chemical fertilizers add in the national economy and the environment. For the mass cultivation of microbial inoculants, bacteria used in soil as biofertilizers need to be multiplied on artificial media to harvest on a large-scale so that it can be supplied to the farmers adequately.

B. **Green manuring:** It is a farming practice where leguminous plants have been denied enough benefits

from its association with appropriate species of *Rhizobium* is ploughed into the soil and then a non-legume is grown and allowed to take the benefit of the already fixed nitrogen. The practice of green manuring was started quite early in several countries. During the course of time, the availability of chemical fertilizers decreased the significance of green manuring. In the recent years, due to the increased cost of chemical fertilizers, the practice of green manuring is re-emphasized. Many leguminous plants are used as green manure. Some of them are cultivated as annual legumes (*e.g.*, *Crotalaria juncea, Crotalaha striata, Cvamposis pamas* etc.), perennial legumes (*e.g.*, *Acacia nilotica, Cassia hirsuta, Sesbania aegyptica* etc.) and wild annual legumes (*e.g.*, *Cassia cobanensis, Lathyrus sativus, Mucuna bracteata).* Report of International Rice Research Institute, Philippines suggested that fast growing tropical legumes can accumulate more than 80 kgN/ha when grown as green plants. Besides, nitrogen, green manures also provide organic matter, N, P, K and minimize the number of pathogenic micro-organisms in soil. Many small and marginal farmers are using green manures because of high cost of chemical fertilizers.

2. Blue green algae (Cyanobacteria)

Role of blue green algae (*e.g.*, *Milosira, Anabaena, Nostoc* etc.) in the paddy field was realised. In water logging condition, the cyanobacteria multiply, fix atmospheric nitrogen and release amino acids, proteins and other growth promoting substances into the surroundings. A good amount of work done at Central Rice Research Institute, Cuttack, Indian Council of Agricultural Research, New Delhi, Banaras Hindu University, Varanasi etc. has been of much importance. Watanabe *et al* (1995) developed

techniques for mass cultivation of blue green algae to use them as biofertilizers in paddy fields. Venkataraman (1961) coined the term 'algalization' to denote the process of application of blue green algal culture in the field as biofertilizer. He has developed the algalization technology in India and transferred to farmers who hold the small land pieces. At present algalization is followed in Maharashtra, Tamilnadu, Uttar Pradesh, Andhra Pradesh, Karnataka and Haryana. Algalization is also being practised in many countries like Egypt, China, Philippines etc. In 1990, Department of Biotechnology, New Delhi has launched a programme under Technology Development and Demonstration Project on cyanobacterial biofertilizers in Uttar Pradesh (Lucknow), Tamilnadu (Madurai),West Bengal (Kolkata) and New Delhi.

As a result of these studies, cyanobacterial biofertilizers were found useful, specially to small and marginal farmers of the country. It was observed that, the cyanobacterial biofertilizers not only increase the productivity and quality of paddy but also minimize the harmful effects of the chemical fertilzers. The objectives of the programme were:

(i) to develop low cost indigenous technology for the mass production of cyanobacteria,
(ii) to isolate region specific fast growing and better nitrogen fixing strains.
(iii) to develop starter inoculum and to demonstrate in field,
(iv) to demonstrate the farmers in field, and
(v) to study the benefits from both economical and ecological point of view.

For the mass cultivation of cyanobacterial biofertilizers strains of cyanobacteria used are species of *Anabaena, Nostoc, Aulosiara, Plectonema, Tolypothrix* are

generally used as starter inoculum. Four methods are used for the mass cultivation of cyanobacteria. These are: cement tank method, shallow mental method, polythene lined pit method, and field method.

The polythene lined pit method is most suitable for small and marginal farmers to prepare algal biofertilizers. In this method, small pit are prepared in the field and lined with thick polythene sheets. Mass cultivation of cyanobacteria is done by using any of the suggested methods. The general methodology is as follows:

1. Prepare cemented tanks, shallow trays of iron sheets or polythene lined pits in an open area. Width of tank or pit should not be more than 1.5 m. It will help the proper handling of the culture.
2. Now transfer 2 to 3 kg soil and 100 g super phosphate. Water the pit about 10 cm in depth. Mix the lime to adjust pH 7. Add 2 ml melathion to protect the culture from mosquitos. Mix it well and allow to settle down soil particles.
3. When water becomes clear, sprinkle 100 g of starter inoculum on the surface of water.
4. During summer, when temperature remains 35° to 40°C the optimum growth of cynobacteria is achieved. Always maintain the water level upto 10 cm during this period.
5. After drying the algal mate, separate it from the soil and form the flakes. During summer, about 1 kg pure algal mat per m^2 area is produced. These algal mats are collected, powered and kept in sealed polythene bags and are supplied to the farmers. These algal flakes can be used as starter inoculum, if the same process is repeated.

Azolla and *Mycorrhiza* are also used as biofertilizers. *Azolla* is an aquatic heterosporous fern which contains an

endophytic cynobacterium, *Anabaena azollae,* in its leaf. *Mycorrhiza* (root fungus) develops as a result of mutualistic symbiosis between some specific root inhabiting fungi and plant roots. In recent years, the use of artificially produced inoculum of mycorrhizal fungi has increased. Due to its multiferous role in plant growth and yield, resistance against climatic and edaphic stress, pathogens and pests; the *Mycorrhiza* spp. have attained great importance as a biofertilizer.

Applications of biofertilizers

The applications of biofertilizers are as follows;

1. It is a low cost technology and can be used by small and marginal farmers.
2. It is free from hazards of pollution and increases soil fertility.
3. Algal biofertilizers increase rice yield upto 10 to 45% and about 40 to 50 kg nitrogen is still left in the soil in turn is used by the subsequent crops.
4. The mycorrhizal biofertilizers make the host plants to reduce plants response to soil stress and increase resistance in plants. In general, certain elements in it increase longevity, growth, survival and yield in plants.
5. The biofertilizers improve physico-chemical properties of soil *viz.*, soil structure, texture, water holding capacity, cation exchange capacity and pH by providing several nutrients and sufficient organic matter.
6. Biofertilizers increase the productivity of crops also.

Thus, biofertilizers are important, if we wish to ensure a healthy future for the future generation.

VERMICULTURE

Vermiculture is a scientific method of feeding, breeding and rearing particular species of earthworms in the shortest time and space by providing improved ideal conditions artificially or in semi-natural conditions. Literally, 'verms' means 'worms' (earthworms) and 'culture' means 'farming'. Different species of earthworms have different requirements for ideal development, growth and productivity. Earthworms play a vital role in soil management and organic waste recycling. Vermiculture also helps in easy production of selected species of earthworms. This industry includes the raising and production of earthworms and their byproducts. Rapid mass multiplication of earthworm becomes possible when we provide them optimal environmental conditions and feed them suitable biodegradable mixture of organic materials. Vermiculture may be extensive or intensive type. Thus, vermiculture is the process of rearing and breeding of earthworms and the technology developed is referred as 'Vermiculture technology'. In many places, vermiculture and vermicomposting are done simultaneously. In fact, the vermicompost is the outcome of earthworm's activity on different kinds of biowaste materials.

Many scientific studies have revealed that earthworms are one of the ideal potential bioresources which can be harnessed and extensively used for human benefits and welfare. Vermiculture confined in vermibins has become more popular as it prevents the chances of adverse effects on earthworms. Vermibins helps in easy management with controlled watering of a large population of earthworms at a particular confined place with required facilities for the rapid multiplication of earthworms. Vermiculture is not only concerned with quantitative growth but also with improving the quality of agricultural produce.

Types of vermiculture

Earthworm raising (vermiculture) is a simple technology which neither needs expensive laboratories nor sophisticated equipments. It can be simply managed on a small scale as an indoor activity by providing proper shelter and avoiding direct sunlight or heavy down pour. However, large scale production has to be done as an out door activity.

Small scale vermiculture can be managed in an inexpensive manner, in flower pots (pot culture) or in pits (pit culture). However, efficient controlled earthworm rearing can be done in specially constructed vermibins with proper protection from enemies and hostile environmental conditions. Cement tanks of 1m x 1 m x 0.3 m can accomodate 1000 worms. The length of vermibins can be increased according to the need. Discarded wooden boxes, plastic trays and buckets etc. can also be used for the vermiculture. Only precaution to be taken is that the constant moisture of 40 to 50% should be maintained by sprinkling water regularly.

Feed for vermiculture

Any organic material mixture which has undergone proper partial microbial degradation can be a good food source for the vermiculturing. The feed for vermiculturing varies with the species. For the initiation of vermiculture, nitrogenous rich organic waste material mixture is a good food. Dry powdered cattle dung or biogas slurry can be mixed with other organic wastes to make the feed more palatable and acceptable. Poultry droppings and cattle dung mixed in 1:1 ratio is ideal for the mass cultivation of earthworms. For mass multiplication of earthworms, waste vegetables, kitchen wastes, agrowastes, cattle, horse, sheep dung etc. can be mixed and used. Sprinkling small quantity of powered rock phosphate helps in quick decomposition.

Species selection

The species of earthworms, *in toto*, are not suitable for vermiculture. Species selection should be done accordingly to the requirement. The selected species of earthworms should have the following important features:

1. Selected worms should be disease resistant, adaptable to climate and should be easily cultured.
2. The species should be efficient converter of biowastes.
3. They should have wide range of feeding, good rate of consumption of agricultural and animal wastes,digestion and assimilation (high metabolic demand) and should successfully reproduce under rearing conditions.
4. Rate of growth must be high and manuring should be fast.
5. The common species of earthworms which can be used for vermicomposting are *Eisenia fetida* (manure worm), *Perionyx excavatus* (Oriental compost worm), *Amynthas morrisi* (for deep pits), *Lumbricus rubellus, Drawida willsi, Lampito mauritii* etc.

Vermiculture: A modern perspective

Present trend is to use earthworms for the wider utilization of-

1. Waste decomposition and waste management.
2. Minimizing the pollution hazards caused due to the accumulation of organic waste.
3. Production of good quality organic manure (vermicompost and vermiwash) for eco-friendly agriculture and horticulture.
4. Production of cheap animal protein (vermiprotein) for livestock.
5. Conversion of wasteland into productive land.

6. Eco-friendly weed management.

In many countries, worms and their droppings are now big business ventures. In many western countries, certain species of earthworm (*Eisenia fetidas* etc.) have been effectively used in sewage sludge management (*i.e.*, to treat the solid end product of sewage). In nature, earthworms are the best garbage converters. To prevent waste water pollution from sugar mills, paper mills, distillary wastes, food processing units etc. earthworms are used as 'vermifilters'. In some places, earthworms are used to convert the organic part of municipal solid waste materials into nutritive rich manure.The sugar industry provides sugarcane waste (press mud) which is good for the earthworms growth. After recovery of biogas, the biogas slurry can be easily used for vermiculture. It is estimated that about 60% solid waste in nature can be used for vercomposting in India. Cuba, Mexico, Philippines, France, Australia etc. have taken up earthworm industry as a profitable business and they have used all the benefits of earthworms to the mankinds. They have now developed good vermicomposting facilities. In simple words, we can say that they have given importance for soil-plant-animal soil recycling system which is eco-friendly, economical and can be operated by earthworms on the principles of bioprocessing and bioconversion in organic recycling. *Eudrilus eugaeniae* can be easily mass cultured for the vermicomposting and surplus worms can be marked as animal feed for poultry, piggery, fish culture, beside educational and research purposes. Thus, vermiculture has good potential to become an ideal cottage industry in countries like India.

Today, we look for new scientific ways to save our deteriorating environment and to improve the general quality of life. We must try to see the ways and means by which earhworms can find a real valuable place in the new

scheme of things in waste disposal, strip mine reclamation, live stock feed, monitoring of pollution etc. Growing common edible mushrooms by using composted rice-straw with earthworms has now become a multimillion dollar business in Taiwan, Philippines etc.

VERMICOMPOSTING

Vermi composting is a phenomenon of compost formation by the earthworms. Obviously, earthworms play an important role in cycling of plant nutrients, turnover of organic matter and maintenance of soil structure. They can cousume 10 to 20% of their own biomass per day. The most important effect of earthworm in agro-ecosystem is the increase in nutrient cycling particularly nitrogen. In several countries including India significant work has been done towards vermi composting. The scientists of Indian Institute of Science, Bangalore have developed method for the frequent decomposition of coconut coir by using earthworms. Thus, vermicomposting (earthworm composting) is the highest grade of composting of decomposable biowastes by the action (ingestion and egestion) and biological degradation by earthworms in short duration. Vermicomposting is the process of converting organic wastes by earthworms into valuable, superb organic fertilizer. It is very effective, eco-friendly and cheap. The method of recycling biodegradable wastes using selected species of earthworms is easy to do also. During vermicomposting not only the bad smell is eliminated but a reduction of many pathogenic organisms also takes place.

Recent researches have revealed that vermi composting is a unique, innovative method of solid waste management for better environmental quality. Vermi composting is something like nature's 'black magic' in

which the selected species of earthworms are the real magicians (biomanagers) and assoiciated micro-organisms are the co-workers.The real magic here is the production of 'black gold' (vermicompost), a unique, wonderful, organic soil amendent from all discarded biowastes which otherwise causes pollution. Vermicomposting helps in conserving and converting all organic wastes for soil fertility maintenance and sustainable crop productivity in an eco-friendly action.

Organic farming through vermicomposting

In present days, modern agriculture system is followed by the farmers. They are using chemical fertilizers and pesticides for higher yield which result into a serious threat to the environment and health. Increasing chemical fertilizer input cost, soil health sustainability and pollution consideration etc. have led to renewed interest in the use of organic manure like vermi compost, which is ecologically acceptable and economically viable. Utilization of vermicompost (organic matter composted by the earthworms) is the best possible answer for the sustainable, modern agriculture system followed by the farmers. They are using chemical fertilizers and pesticides for higher yield which results into a serious threat to the environment and health. Earthworms in organic farming help us to avoid the dumping off thousand of tonnes of agro-chemicals on the earth every year and to give residue free food, safe environment and a better living standard. Vermicomposting of biowastes not only minimizes the pollution effects but also helps to get safe, healthier, higher yields at a relatively low cost without deteriorating of the soil health. Thus, the earthworms used for vermicomposting may be referred as biomanagers, ecosystem engineers and decomposer industry etc.

Raw material for vermicomposting

Any biologically degradable and decomposable organic matter with atleast 1% nitrogen can be easily used as food for earthworms in vermicomposting. The organic material that is used to feed the worms by worm growers is known as 'feed stock'. The material used for the vermicomposting are as follows:

1. **Animal dung:** Dried dung of cattle, sheep, goat, horse, elephant, pig, rabbit, dropping of poultry, biogas slurry etc. are the materials used.
2. **Agricultural wastes:** Vegetable wastes, fruit rinds, leaf-litter, weeds, stem etc. are used for vermicomposting.
3. **Forest wastes:** Forest leaf litter, wood shavings, grasses, weeds, saw dust, pulp etc. are used for vermicomposting.
4. **City refuge:** Kitchen waste from house holds and restaurants, market wastes, paper wastes, cotton cloth, newspapers, egg-shell and all other kinds of decomposable city refuge is also used.
5. **Industrial wastes:** Different types of agro-industrial wastes from food processing industries, distilleries, sericulture, sugar factory, car industry, seed processing units, oil extracting units etc. are good raw materials for vermicomposting.

For vermicomposting, it is better to have a heterogenous mixture of different varieties of organic wastes (for maintaining C:N ratio) so as to maintain nutritional balance, aeration, moisture etc. in the raw composting material. It should be interested to note that the nutritive value of the vermi compost depends greatly on the raw materials used. The quality of the vermi

compost can be improved by adding rock-phosphate, neem-cake etc. Following raw material for the vermicomposting are not used: dairy foods, fats, oily foods, excreta of canines, meat eaters *e.g.*, dogs and cats). Some citrus fruits such as (orange, lemon etc.), garlic, onion, cloves, hot and heavy spiced food wastes, high acid foods etc. should also be avoided as ingredients in the raw materials for vermi-composting.

Preparation of vermicompost

It can be prepared in the following way:

1. Take a clean large earthen pot and close the holes at the bottom with gunny bag pieces. Prepare vermi bed by using coconut coir and sprinkle a handful of sieved garden soil for introducing beneficial micro-organisms.
2. Collect decomposable biowastes and add into the pot. Add cowdung slurry or cowdung and water to make a mixture in the ratio of 3:2. If available add 1-5% rock phosphate for increasing nutrient contents and hastening the process of decomposition.
3. Maintain physico-chemical characteristics of the biowaste such as moisture (40 to 50%), temperature (26 to 35 °C), pH (6 to 7.5) etc. Sprinkle small quantity of lime to prevent acidity.
4. Mix all the contents well and allow it to undergo primary decomposition for 15 to 20 days. Precaution should be taken to prevent water stagnation and anaerobic condition.
5. Add selected species of earthworms, *i.e.*, *Eisenia fetida, Eudrilus eugeniae* or *Perionyx excavatus* etc. @ 100 worms/kg organic contents.
6. Regularly sprinkle water to maintain moisture content (of water) about 40 to 50%. If necessary give

proper aeration. Processing of vermicomposting will be completed within 2 to 3 months. Watering should be stopped for 2-3 days before harvesting.

7. For harvesting of vermicompost, the vermi-composted material is dried in shade by keeping it in a conical mound. Remove rest of the vermi composted material and pass it through sieves of 3 mm (galvanised mesh). Pick up the earthworms cocoons which can be used again for vermi composting. Now the vermi compost is ready for packing in the polythene bags with 8 to 10% moisture.

Thus, in general, we can say that the vermicompost contains atleast 1 to 1.5% N, 0.8% P, and 0.7% K apart from micro-nutrients, many beneficial microbes and biologically active metabolites are also produced. Efficiency of the vermi compost can be studied by growing different crops and plants.

Vermiwash (worm tea)

Vermiwash is a kind of organic liquid fertilizer obtained in the form of watery extract that comes from the vermibin outlet as drainage. In other words, vermiwash is a clear transparent, yellow coloured aqueous extract collected after the passage of water through a column of worm culture. This extract contains many excretory products and excess of secretions of earthworms (*e.g.*, coelomic fluid) with some dissolved plant nutrients, enzymes, group B-vitamins and plant growth factors which stimulate the growth and yield of crops and even help increase disease resistance power in crops.Vermiwash can be used in nurseries, lawns and orchards. Vermiwash is an ideal for foliar spray or it may be applied to the root zone of plants.Vermiwash can be diluted with cow urine or neem extract, garlic extract and can be used as natural biopesticide for agriculture crops. Vermiwash can also be added into the compost pits to

hasten the process of degradation. Vermiwash has been found to inhibit the mycelial growth of pathogenic fungi.

Applications of vermi composting

Applications of vermicomposting are as follows:

1. Vermicompost helps to improve the physical, chemical and biological properties of soil in the long-run on repeated application.
2. Vermicompost has high water holding capacity due to its strong hygroscopic mucous coated spongy aggregates. In sandy soil, where there is problem of water retention, it helps to hold water for long time.
3. Vermicompost not only helps to improve the soil quality and fertility but also stimulates the plant growth.
4. It also helps to control certain diseases that attacks plants.

TERMINATOR SEED TECHNOLOGY

Terminator seeds are produced by the transgenic plants. Normally they produce a normal crop and normal seed are set up by this crop. But if the seeds are treated with specific chemicals like tetracycline, they produce normal crop but the seeds obtained from this crop can not germinate as they contain non-viable embryos. Such technology is referred as 'terminator seed technology'.

Potential risk and benefits of genetically modified organisms released into the environment have been largely debated within the political and scientific communities. Available studies on the ecological impact of transgenic crop plants have shown that the risks and benefits are difficult to assess in field experiments.The following example is suggested that the risk are involved in the

production of genetically modified organisms. The laboratory based work on pollen from maize which were engineered with *Bacillus thuringiensis* (BT) insecticide gene. Such pollen grains have been found to be harmful not only to the target organism, European comborer but also to the nontarget monarch butterfly. BT cotton seed is another example.

The fundamental environmental risk of transgenic crop is related to the fact that almost nothing is known about the fate of transgenes after their release in the field. Recent studies have shown that engineered genes can be transferred from genetically modified (GM) plants into the soil bacteria, raising concerns over the dissemination of transgenes into the environment by means of indigenous terrestrial micro-organisms. Consequently, it is necessary to mention that a major environmental risk is associated with terminator gene technology concerning more than 1 billion poor people whose main food source is based on replanting second germination of seeds. The introduction of lethal genes in crops *viz.*, rice and wheat would have a great impact on the fate of millions of people who may be affected by the impact of these genes on the people and non-target organisms.

Terminator seed technology employs three specific genes, *viz.*, gene A, B and C. Gene A encodes for a protein having lethal effects *e.g.*, ribosome inactivating protein. Gene A is transcribed only in embryo during the late stages of their development. Besides, gene A coding sequence is interrupted by placing within it a blocking sequence flanked by a specific excision sequence. This complete construct constitutes the gene system II of terminator seed technology. This blocking sequence has to be removed from the gene system II to enable expression of gene A and consequent production of ribosome inactivating protein. The gene C, a regulator gene which encodes a repressor

for the other gene, say gene B. This gene is active when in native state but it becomes inactive as a result of an interaction with a specific but simple chemicals *e.g.*, tetracycline.

When the seeds are treated with specific chemicals like tetracycline, the chemical enters into the cells of germinating seedling. Tetracycline renders the repressor of gene B active, as a result of which gene B is expressed and recombinase is produced. The recombinase excises the blocking sequence present in gene system II and as a consequence genes A can now be expressed and produced. The *lea* promotes, which drives gene A, not to allow its transcription until the crop has grown and began to produce seeds. The *lea* promoter limits the expression of gene A to the cells of the embryos in late stages of development. Production of these cells blocks the synthesis of proteins essential for embryonic vitality. As a result, the seeds produced by a crop derived from tetracycline treated seed, cannot germinate.

Besides terminator seed technology, several second generation technologies are being developed. These technologies called terminator-2 technology, verminator technology or traitor technology whose aim is to disable critical plant functions governing reproduction, disease resistance and plant growth. A generalised name for these technologies is 'gene use technology' as they prevent the use of concerned transgenes in breeding programmes without consent. The negative impacts of terminator seed technology have risen to an unacceptable level. Therefore, more and more research is needed in this area before making the technology acceptable.

QUESTIONS

1. What is bioremediation? Give an account of *in-situ* and *ex-situ* bioremediation.

2. Explain bioremediation of wastes. How it will be a good tool for environmental clean up?
3. Discuss the biofertilizers. Add a note on their application.
4. Give an account of vermicomposting.
5. Write short notes on:
   A. Bioremediation
   B. Biofertilizers
   C. Vermiculture
   D. Vermicomposting
   E. Vermiwash
   F. Terminator seed technology
   G. Environmental biotechnology

22

BIOPIRACY

Today's world is a fast moving world. During the process of development, many changes have taken place. One of the important word used these days is 'biopiracy'. The meaning of the word is stealing, theft, thieving, thievery of biological aspects or materials etc. It can be defined as the commercial development of naturally occurring biological materials *viz.*, plant substance or genetic cell lines, by organization without fair compensation to the people or nations in whose territory, the materials were originally discovered. Biopiracy is a biological theft, or illegal collection of indigenous plants by corporations who patent them for their own use. It is an act of taking something from someone unlawfully.

A decade ago, there were no laws about what you can or can't take from the nature. The legalities of obtaining samples of plants, microbes and animals were straight forward. In many cases, the researchers could simply arrive at a field site, collect samples and take them home. There was no applicable law. He might obtain informal permission from a local community or landholder as such for being on the land and for collecting the biological materials. At the most, the researchers might be required to obtain a permit to collect from national lands like a fishing or hunting license. "Take-and-run" can explain the

old approach to collection. Scientists used to take specimens from anywhere in the world without much repercussions.

BIOPIRACY: THE LEGAL PERSPECTIVE

The history of international plant collecting missions goes back 3,500 years at the time of Egyptian rulers. In the last couple of centuries, the British Empire instituted regular plant collections. During the voyage of Beagle, Charles Darwin simply took what interested him, from the Galapagos and elsewhere, and brought it home. Similarly, the Royal Botanical Gardens took rubber trees from Brazil and planted them in South-East Asia. They took Cinchona seeds from Bolivia, in violation of national law and planted them in India. Commodore Perry and his group collected a wide variety of plants in Japan and bring back to the U.S. The adventures of Richmond Schultes during the mid twentieth century have become a legend among ethnobotanist. He was able to become a friend of a local Shanmans, who allowed him to collect thousand of voucher specimens of medicinal plants, hundred of which had never previously been identified taxonomically. Nobody was challenged on legal grounds to these trips. If this would have been done today, it would have been challanged in the court of law.

New rules of bioprospecting

There are three new rules of biodiversity prospecting and natural products. These are: International treaties, National laws and Professional self-regulation.

1. International treaties

The Convention on Biological Diversity (CBD) in 1993 established sovereign national rights over the biological resources and commits member countries to conserve them, develop them for sustainability and share the benefits resulting from the use. Sustainable use of

biological resources means finding new drugs, crops and industrial products. CDB provide access to genetic resources while conserving the resources for future studies. To satisfy the three goals of CDB (Conservation, Development, and Benefit sharing) that can be applied through access and benefit sharing agreements. Under CDB, the source country providing access to genetic resources must know in advance what will be done with the resources, and what benefits will be shared. Benefits may include support for research and conservation, contributions of equipments and materials, assistance to indigenous and local communities, up front fees, milestone payments and royalties.

2. National laws

Through laws the countries have began to exercise their sovereign rights over biological resources as per the CDB. Many of these laws have created a new category of poaching, in which biological materials are collected or exported without obtaining permission (informal consent) and satisfying certain conditions such as benefit sharing.

3. Professional self-regulation

Meanwhile, many institutions and professional organizations have decided to implement natural products research policies for their members, and these policies have quasi-legal or contractual status. For example, botanical garden, biotechnology companies and professional groups.

The cónsequences of breaking the new rules are very simple. The people, who collect biological samples to follow the new rules are informed of consent and benefit sharing. The consequences of following the old "take-and-run" approach, biopiracy is extremely serious.

Patents on natural products inventions are subject to attack unless all public knowledge about the species

in question and its uses are fully disclosed. Organizations in the bioresources rich but economically poor countries of the developing world have demonstrated a willingness to attack natural product patents on the the basis of traditional knowledge, motivated by principles of justice rather than the economic force ususally underlying patent disputes. For instance, a patent 'Use of turmeric in wound healing' was cancelled in 1998 by Council of Scientific and Industrial Research, New Delhi. The new evidence established that the use of turmeric to promote wound healing had been known from generations in India.

If a researcher removes biological material illegally from a source country, and then gets profit from the material, the source country or affected person could recover all or some of the profit, in the U.S. court. Thus, there is a real legal risk for someone who fails to reach agreement on an access and benefit sharing agreement before taking a sample to the home, Collection of biological material without a benefit sharing agreement is likely to find its way into the list of criminal violations in some countries, so that biopiracy could result in a jail.

Consequently, the legal tools are being developed in developing countries and other biodiversity rich countries may exert greater leverage over the use of their resources. This leverage can be used to earn revenues, promote conservation, and train and educate people. According to E.O. Wilson "useful products cannot be harvested from extinct species". The most fundamental risk is to natural products research is continued loss of biodiversity. If the new rules for biodiversity prospecting succeed in reducing biodiversity loss, while allowing research to continue, any inconvenience they bring will be justified. Hopefully, the new system will work, and we will find effective ways to work within it.

Biopriracy and intellectual property rights

Global corporations are scouring the world, extracting the genetic material, then patenting, these findings as their discoveries. Whilst the west is not immune from this practice, the Third World is targeted as it has the richest genetic diversity. Historically, the patents have served to protect the lone inventor from being ripped off by big business, though whether he can afford to establish his right in law is another matter. Patents and Intellectual Property Rights exist to award intellectual endeavour. On the basis of the current granting of patents, Newton could have patented the laws of Gravity, Einstein's theory of Relativity, new planets could be patented and a royalty could be charged for anyone who choose to look at them etc. Endangered indigenous people are having their genes sampled and stored in gene banks against the day when their race becomes extinct. If they are lucky, they receive a token payment. UNESCO's International Biotechnology Committee has endorsed the criticisms raised by indigenous people. No intellectual endeavour is involved in the automated cataloguing of genes. The discovery of genetic links to the diseases are being patented. This means that anyone offering a diagnosis or cure based upon the patents will be obliged to pay royalties. Farmers traditionally buy seeds, save from previous crop and share with their neighbours. The saving and sharing of seeds has helped to promote genetic diversity.

The terminator seed technology is the ultimate weapon to ensure that farmers do not reuse seeds as they will no longer be able too. The terminator technology is a biological weapon, which introduces a 'suicide gene' into plants, turning off their ability to produce viable genes. The terminator seed technology should be banned legally to abide by the provisions of Act of 1972.

Growers of seed potatoes in Scotland are being hit hard by the extortionate royalties demanded by plant

breeders. In Iceland, a furious row has broken out following the claim by a corporation that it has the patent rights to all Icelandic human DNA sequences. The neem tree is widely growing in India and seeds have medicianl properties. A U.S. corporation has patented the seeds and is demanding payments for its use. Biocyte has been granted patents in the U.S. and Europe that gives it rights to the blood cells extracted from the umbilical cord of new born babies. Thus, patents on life are not only a gross abuse of the patent system, they are ethically and morally wrong as they treat life as nothing more than a commodity and people and animals no more than machines. Trade Related Intellectual Property Rights (TRIPS) and World trade (or free trade) are closely related. Free trade as embodied by GATT, and its succeessor, WTO is the freedom of global corporation to destruction, pillage and exploition. WTO is a quasi-world government with legislative, executive and judicial powers. It is being run on behalf of global corporation with the help of U.S. TRIPS which was drawn up in the dying days of General Agreement on Tariffs and Trade (GATT) by the Intellectual Property Committee, who had the fortune of 500 companies. One of the role of WTO is to enforce Trade Related Intellectual Property Rights (TRIPS), the other is to tackle no-tariff barriers to trade.

Ecosystem are being destroyed at an alarming rate, 100 species/day face extinction, and the rate is accelerating. The global warming, pollution, rainforest destruction and soil erosion are increasing. These are some of the signs of unsustainable development. CBD in 1993, an outcome of the 1992 Rio Earth Summit, has agreed on international binding to stop destruction, start conservation and sustainable use of biological diversity legally. Intellectual property rights should promote not to counter the objectives of the convention. Biodiversity and our survival depends upon the protection, conservation and free availability of our natural resources,

not on their privatisation by global cooperation. Thus, the biopiracy and intellectual property rights are closely related. Without plundering genetic material and the protection by patents on life, the biotechnology industry would be severally limited in its ability to force its unwelcome products into the world.

Brief history of Intellectual Property Rights in India

In India, innovation and novel techniques were limited with the families or small social groups. There was no other system of protecting their rights. For this purpose, in 1856, Government of India introduced the 'Act of Protection of Inventions'. This act was based on British Patent Law (1852). After this, Patent and Designs Protection Act came into existence. In 1888, Inventions and Designs came under the management of Controller of Patents and Designs. In 1970, Indian Patent Act was passed. This is a currently operative Patent Act.

Intellectual property rights

Intellectual property rights are patents, designs, trade marks, geographical indications and copyrights. All these IPRs play an important role in the international trade and commerce and also in the industrial, economical and social development of the nation. India has made a great progress in grant and exploitation of intellectual property rights. As a result, IPR related activities have been increasing continuously in the country for the last several years.

1. **Patents:** A patent is a right granted by the government to an inventor to exclude others from imitating, manufacturing, using or selling the invention in question for commercial use during the specified period. Patents are granted for an invention, innovation or improvement in an invention, the process or product of an invention,

and a concept. Beside these, a patent is limited for both in time and space. A patent is valid for specific period from the date of its award. In most of the countries, this period is varied from 15-20 years. In India, head office of patents is in Kolkata and branch offices are located in Chennai, Mumbai, and New Delhi. The office of the Patent Information System (PIS), established in 1980 at Nagpur, maintains the collection of patent specifications and patent related literature on a worldwide basis and also provides technological information in the patent or patent related literature through search services to the user of R & D laboratories, government offices, private industries and other users in India.

2. **Designs:** Design is a creative activity which results in ornamental or formal appearance of a product. For the protection of designs, there is a design right. The design right refers to the novel or original design that is accorded to the proprietors of a validily registered design. Industrial designs are an element of the intellectual property. Under TRIPS agreement, minimum standard of protection of industrial designs have been provided. India, as a developing country, has already amended its national legislation to provide the minimal standards. The existing legislation on industrial designs in India is contained in the New Design Act, 2000. This act will serve its purpose well in the present time of rapid changes in technology and international developments.
3. **Trade Marks:** The Trade Marks Registry was established in India during 1940 and presently it administers the Trade Mark Act, 1999 and rules there under. It acts as a resource and information centre and is a facilitator in matters relating to trade

marks in the country. The objective of the trade mark act, 1999 is to register trade marks applied in the country and to provide better protection to the trade marks for goods and services and also to prevent fraudulent use of the mark. The main function of the registry is to register trade marks which qualify for the registration under the acts and rules.

4. **Copyrights:** There are some intellectual properties which we can not make its patents. Such properties are protected by copyrights. Copyright properties include authored and edited books, audio and video cassettes etc. The copyright of a book may be held by the author, editor or publisher. Now a days, copyrightable software's are also available. The copyright is limited to both time and space. It provides protection for a specific period and only from the reproduction. However, it does not prevent another person from using the either idea or information contained in a copyright material.
5. **Geographical Indications:** Geographical indications (GIs) cover the qualities, reputation or other characteristics of a product that could be used to recognized that a particular product is originated from the particular territory, region or locality. Some examples of products that comes under the geographical indications are Scotch Whiskey, Champagne and California wines. There are some legislation for GIs which specify that the products have been accepted in terms of quality and other characteristics that originated from the given specific locality. The chief requirement for the GI protection is that a given quality, reputation or other characteristics of the product. The GIs covers the agricultural goods, natural products, manufactured products, handicrafts and food products. Geographical Indication Act, 1999, claim GI for a

variety of goods, including Basmati rice. GI protection is recognized under TRIPS (Trade Related Intellectual Property Rights) of GATT (General Agreement on Tariffs and Trade, 1994).

Rules for the Intellectual Property Rights

These are:

A. **Novelty:** The invention must be new and should not be already known to the public.
B. **Inventiveness:** The invention should be innovative.
C. **Industrial application and usefulness:** The subject matter must have an industrial application, either immediate or in the future, and it should be useful to the society or to the nation.
D. **Patentability:** The subject matter must be patentable under the existing law and its current interpretation.
E. **Disclosure:** The disclosure of an invention gives an opportunity to other inventors to improve upon the various features of the invention, which results in scientific and economic progress of the society as well as of a nation.

Benefits of Intellectual Property Rights

The benefits of Intellectual Property Rights are as follows:

1. It gives protection to the intellectual and artistic creations.
2. It encourages investments in Research and Development efforts.
3. Intellectual Property Rights enable the dissemination of new ideas and technologies quickly and widely.
4. It also provides consumers with the results of creations and inventions.

5. Intellectual Property Rights increase opportunities of distribution of above effects to national as well as international level of industrial and economical development.

Problems with Intellectual Property Rights:

The problems with Intellectual Property Rights are:

1. It encourages monopolies.
2. It perceives threat to the food security.
3. Intellectual Property Rights may adversely affect the biological diversity.
4. In many cases, the IPR situation is very complicated.
5. Intellectual Property Rights may be detrimental to the livelihood of the poor in the developing countries.

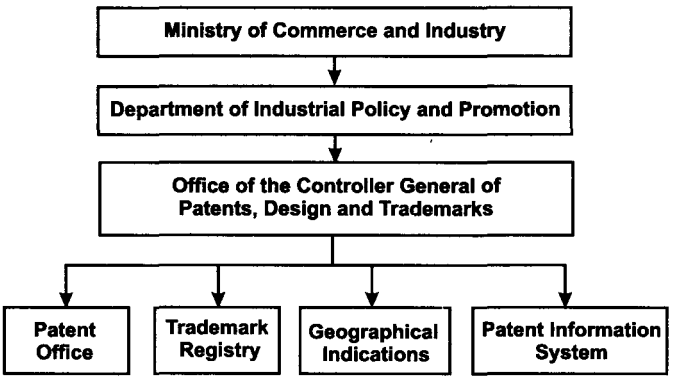
Offices and organization of Intellectual Property Rights

1. Offices

The office of the Controller General of the Patents, Designs and Trademarks (CGPDTM) is located in Mumbai. Head office of the Patent is in Kolkata and its branch offices are at Chennai, Mumbai and New Delhi. Trade Marks Registry is in Mumbai and its branches are located in Kolkata, Chennai, Ahmedabad and New Delhi. Designs office is located in Kolkata in the Patent office. The office of the Patent Information System (PIS) and National Institute of Intellectual Property Management (NIIPM) are at Nagpur.

2. Organization

Organizational details with the hierarchical position of intellectual property offices are shown as follows:


Ministry of Commerce and Industry
Department of Industrial Policy and Promotion
Office of the Controller General of Patents, Design and Trademarks
Patent Office
Trademark Registry
Geographical Indications
Patent Information System

Advantages and disadvantages of Patents and Intellectual Property Rights

For many companies, patents and intellectual property rights can be a great things because they allows them to recoup any cost they incurred in the development of their products but the patents are really beneficial to science in any other way than for the use of recouping R and D costs? There are two different approaches to evaluate the usefulness of patents in science. One approach is an attempt to decide the benefits of the patents or Intellectual Property Rights. Second approach is to determine the reward for all the intellectual labour that was put into the development of the product. The possible benefits could be the advancement of medical research, biotechnology, medical drugs, and many other forms of technology. Other negative issues of patents is its expiry date. It may be around 17 years. It is interesting to note that patents and Intellectual Property Rights are an appropriate rewards for an individual's or company's hard work. We can say that patents are appropriate because someone who puts enormous amount of time and money into reaching and developing a product should be rewarded, so that other people can not steal the ideas or products and sell, if for

their own gain. That would serve to be a serious disadvantage for the creator of the product and a patent would alleviate the risk of such disadvantage.

To understand the advantages and disadvantages of Patents and Intellectual Property Right, it is useful to evaluate and discuss on the matters given by Vandana Shiva (1997) in her paper 'Knowledge, creativity, and Intellectual Property Rights'. She quotes "Intellectual property rights on life forms are supposed to reward and stimulate creativity. Their impact is actually the opposite to stifle the creativity intrinsic to life forms and the social production of knowledge". According to this quotation, the patents are not necessary for creative research. She also evaluates that patents promote more important research which leads to bigger and better discoveries. Shiva makes the argument that Intellectual Property Rights are only recognized when knowledge and innovation generate profits, and not when they meet social needs. This claim is false because they don't only generate profits, and even if patents generate profits they help the patent holder recoup costs for the labour and to generate a profit in a descent way.

Shiva makes third claim that patents and Intellectual Property Rights promote a culture of silence between scientists. This claim holds some merits but it may not entirely correct. Though, the Patents and Intellectual Property Rights can make claim on nature does not mean, thats wrong and even when they do, whatever innovation is being claimed has to be altered to some degree, so that it can be patented. Therefore, in essence one is not patenting the original variety but a brand new one.

Effects of Biopiracy on Intellectual Property Rights

Biopiracy is becoming a bigger threat in today's society as it undetermines the patent system that is in place and it also causes harm to whom ever since the product was

pirated. This can be well understood from the following example. The Enola bean case is probably one of the case of biopiracy. In this case, a man named Larry Proctor had purchased a package of beans in Mexico. He took the beans which he purchased and through plant breeding techniques created a new variety of beans with distinct characteristics from the original beans. Proctor then applied for a patent and a PVP certificate, covering any bean that was coloured similar to his beans. Proctor was granted his patent and certificate and then he sued few small companies and farmers co-operative societies that were selling a bean similar to the one he developed. The only problem was that the beans were sold by small companies from Mexico as well as had been grown there for centuries. Not to mention, it was almost genetically identical to Proctor's bean. This is clearly a case of someone travelling to remote location, pirating a local product and then trying to patent it in the U.S., all to make a quick bucks. This case undetermines the entire patent system because the patent was not granted to the correct person and the country that the product came from is also being harmed because they do not reap any of the benefits from the patent.

After careful scrutiny, it is clear that the current patent system has its flaws and need to be worked out. It is also cleared that the patents are good thing as long as they are not granted for pirated material. It is to say that the patents do spur some form of creativity, but the patents and money are not only cause of the creativity. The benefits of the patents out weigh the costs over the long run as long as patent holders don't use loop holes to gain more patents on essentialy the same product.

QUESTIONS

1. Define the biopiracy. Explain its legal perspectives and new rules of bioprospecting.

2. Discuss the biopiracy and Intellectual Property Rights.
2. Write an essay on Intellectual Property Rights.
3. Explain the benefits and problems of Intellectual Property Rights.
4. What are effects of biopiracy on Intellectual Property Rights?
5. Write a short note on biopiracy.
6. Explain:
   A. Patents
   B. Designs
   C. Trade marks
   D. Copyright

23

ECO-TERRORISM

During the past two decades, radical environmental and animal rights groups have claimed responsibility for hundreds of crimes and acts of terrorism, including arson, bombing, vandalism and harassment, causing more than 100 million dollar damage. Though, some of activists have been captured, most of the attacks remained unsolved. Although it have been overshaded by muslim terrorist threat. Since 11 September, 2001 attack on the World Trade Centre, the ecoterrorism remains one of the world's most active movement of terrorist. In recent years, an increasing amount of terrorist activity in the United States has been carried out under the title of animal and environmental protection. Automobile dealerships, housing developments, forest companies, corporate and university-based medical research laboratories, restaurants, fur farms and other industries are the targeted spots. Although one has not yet been injured in a domestic eco-terror attack, the increasing violent nature of attacks suggests that someone will be hurt. In a statement, John Lewis (2004) of FBI's counter terrorism division has noted "upswing in violent rhetoric and tactics" among eco-terrorists.

The word 'Eco-terrorism' is a dual word, in which one word is 'eco' and other one is 'terrorism'. 'Eco' means 'environment' and 'terrorism' meaning 'terrorist activities'.

Thus, the word terrorism involves violence and the threat of violence. It includes war, coercive diplomacy, and bar room brawls. Many news resources such as Reuters, avoid to use the term terrorist, instead they are using less accusatory words like bombers, millitants etc. In many countries, the act of terrorism is legally distinguished from criminal acts. As terrorism ultimately involves the use of threat of violence with the aim of creating fear, not only to the victims but among the people. The aim of terrorism is to achieve limited political or other goals, when an out right military domination is not possible.

Eco-terrorism is also called 'Environmental terrorism' or 'Green terrorism'. In free Encyclopedia, Wikipedia, the eco-terrorism is defined as, terrorism conducted for the purpose of ecological, environmental or animal rights cause. The word is a neologism and its applicability is contested. In other words, we can also define the eco-terrorism as the unlawful destruction of resources to deprive others of its use. The Domestic Terrorism Section of the Federal Bureau of Investigations of USA has defined the eco-terrorism as "the threatened use of violence of a criminal nature against innocent victims or property by an environmentally oriented, sub-national group for environmental and political reasons or aimed at an audience beyond the target, often of a symbolic nature". The term is controversial among environmentalists, animal rights activists and others. According to Paul Watson, eco-terrorism is an act that terrorises other species and threaten the ecological systems of the planet earth.

Recently, individuals and governments have become concerned about the possible increased threats of terrorism in new and dangerous forms. Yet traditional military estabilishments and institutions have focussed primarily on traditional threats and have only slowly refocused on ethnic, religious and economic factors that may now motivate terrorist actions. Among these, environmental

conditions and resources may be the targets of terrorists. This has led to environmental terrorism or eco-terrorism. It requires the understanding links among population growth, resources use including water, energy, soil etc. and environmental conditions *viz.*, climate, human health and well being. As the population is growing very rapidly and the available resources are being depleting at fast rate.The value and vulnerability of these resources increase, so they are becoming targets of terrorists. History shows that access to resources has been a proximate cause of war. Environmental degradation and disparity in the distribution of resources causes political controversy, tension and violence.

The act of violence described by authorities as eco-terrorism varies widely. Some act involves sabotage of equipment and unmanned facilities using techniques ranging from equipment destruction to firebombing free spiking, the embedding of metal spikes in trees to deter logging, is sometimes described as eco-terrorism. Most of these acts fail to meet law enforcements defination of eco-terrorism as they lack publicity and symbolic elements. The groups accused of eco-terrorism include the Animal Liberation Front (ALF), the Animal Rights Militia (ARM), Earth First, the Earth Liberation Army (ELA), The Environmental Rangers, the Justice Department, the Revolutionary Cells Animal Liberation Brigade (RCALB) and Sea Shepherd etc.

Eco-terrorism has made distinct from environmental terrorism, which describes as the attacks against environment, or using the environmental or natural resources for political or military objectives. Environmentalists argue that 'eco-terrorism' should mean the opposite of its current accepted meaning. They say that the persons, companies and govenments engaging in ecologically irresponsible activities such as cutting of forests are committing terrorism against the environment.

Organizations that have been labelled as eco-terrorists in the U.S. are Animal Liberation Front, and the Earth Liberation Front. In 2006, several newly constructed homes were burned in the Oyster bay, New York, which was a alleged act of eco-terrorism. In early March, 2008, three large homes went up in flames in a Seattle sub-urban area, apperantly set by eco-terrorists was also a recent alleged act of eco-terrorism. Despite a law enforcement in capturing those responsible for ecoterror related crimes, most acts remain unsolved. Eco terror cells remain extremely difficult to identify and infilterate. It is unlikely that this rapid growing movement will disappear very soon.

HISTORY

The history of eco-terrorism starts with the history of terrorism. It is a history of various types of terrorism and terrorist individuals and groups. The history started before 16th century. In 1985, 816 peoples were killed. It is the highest annual tally until then death decreased upto 1980, then rose to 3,295 in 2001, mainly due to 11th September, 2001 attack on World Trade Center, in which 3,000 lives were lost. In 2003, more than 1,000 people were died due to terrorist act. Many of these resulted from the auto-death bombing in Iraq, Checheniya, Israel and India. It does not tally the victims of state terrorism. The statistical report shows that in 1980s, terrorist attacks were declined in Western Europe. On the other hand, Asia experienced an increase in international terrorist attacks. From 1991 to 2006, there is a consistent increase in number of casualities from international terrorists attacking in Asia. Statistically, distribution of the severity of terrorist attacks follows a power law, much like that for wars and also natural disasters like earth-quakes, floods and forest fire.

INTERNATIONAL CONVENTIONS

International conventions on terrorism set out obligations of states in respect to defending international counter terrorist offences, prospecting individuals suspected of such offences, extraditing persons on request, and providing mutual legal assistance. In broad sense, there are two types of international conventions on terrorism: (i) true international conventions which are open to all states. At present, there are 13 international conventions. Out of which 12 are in force, (ii) regional multilateral terrorist conventions *viz.*, the Council of Europe Convention on the Prevention of Terrorism (2006), the Inter-American Convention Against Terrorism (2002), the Organization of African Union Convention on the Prevention and Combating of Terrorism (1999).

Other international treaties may also be relevant in particular circumstances *viz.*, Bilateral Extradition Treaties, the 1961 Viennna Convention on Diplomatic Relations and the 1963 Vienna Convention on Consular Relations. Now, a number of important United Nations Security Council and General Assembly Resolutions on International Terrorism including United Nations Security Council Resolution 1973, and three important security council resolutions dealing with Libya's conduct.

Like international treaties agreed under the auspices of particular regional organizations and the conventions are generally open for the member states of regional organizations. The principal regional conventions of particular note dealing terrorism and ecoterrorism are as follows:

1. European Convention on the Suppression of Terrorism (1977).
2. Inter-American Convention Against Terrorism (2002).
3. African Union Convention on Prevention and Combating of Terrorism (1999).

4. SAARC regional convention on suppression of terrorism (1987).
5. Arab Convention on the suppression of terrorism (1998).
6. Convention of the organization of the Islamic Conference on combating International Terrorism (1999) etc.

ANTI-TERRORISM LEGISLATION

All types of laws passed in the purporated aim of fighting terrorism are referred as anti-terrorism legislation. It usually includes specific amendments allowing the state to bypass its own legislation when fighting terrorism related crimes, under the grounds of necessity *e.g.*, the various U.K. terrorist acts during the Northern Ireland conflict have severely restricted rights of the defense and terrorists acts. Anti-terrorism legislation endangers democracy by creating a state of exception that allows the style of government. However, most anti-terrorist legislation remain in activity even after the intial target of it has been eliminated. Measures of anti-terrorism legislation includ preventive detention, control orders in the U.K and Australia, warrantless searches in the U.K. etc.

WAR ON TERRORISM

The war on terrorism or war on terror is the common term for the various military, political and legal actions initiated by the U.S. government against the attack of 11 September, 2001 on World Trade Center. Main objectives of this war was to counter terrorist threats, prevent terrorist acts and curb in the influence of terrorist organizations *viz.*, *Al-Quada*. Both the terms justify unilateral war, human rights abuses and other violations of international laws.

The phrase 'War on terrorism' was first widely used by the Western Press to stop attacks by Anarchists against international political leaders. Many of them are described as 'terrorists' and the term had a positive sense like "I am a terrorist, not a killer". In the next time, the phrase gained currency by the efforts of British Colonical Government. On 20 September, 2001, the U.S. President George Bush had formally declared war on terror when he said, "Our war on terror begins with *Al-Quada*, but it does not end there, untill every terrorist group of global reach has been found, stopped and defeated." According to President Bush, the objectives of the war on terrorism are: defeat terrorists and organization; identify, locate and destroy terrorists along with their organization; destroy sponsorship, support and sanctuary to terrorists; diminishing the underlying conditions of terrorists seek to exploit; defend U.S. citizens and interests at home and abroad.

Consequently, the eco-terrorism refers to the terrorism conducted for the purpose of ecological, environmental or animal rights causes. In other words, it is a unlawful destruction of resources to deprive others of its use. The eco-terrorists organization in the U.S. are Animal Liberation Front and the Earth Liberation Front. If we study the history of eco-terrorism, we find that it has started since ancient time. During this period, thousands of people were attacked by terrorists and till today it is continued. To prevent this, there are some international conventions for controlling international counter terrorist offences, extraditing persons on request and providing mutual legal assistance. At present, there are 12 true international conventions in force and regional multilateral terrorist conventions include Europeon Conventions on the Prevention of Terrorism (2006), the Inter-American Convention against Terrorism (2002), Protocol (2004) etc. The anti-terrorism legislation includes preventive detention, control orders and warrantless

searches. War on terrorism refers to military, political and legal actions initiated by the American Government in 2001. It prevents terrorists threats, terrorists acts and curb the influence of terrorist organizations.

QUESTIONS

1. Write an essay on eco-terrorism.
2. Write short notes on:
   A. Anti-terrorism legislation
   B. War on terrrorism
   C. Eco-terrorism

24

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SUBJECT INDEX

A

Abiotic components, 6, 32
Acid rain, 201
Age distribution, 73
Air pollution, 199
Algal bloom, 214
Anti-terrorism legislation, 308
Aquatic ecosystem, 30
Artificial ecosystem, 31
Atmosphere, 6, 9
Autecology, 3
Autotrophs, 33

B

Benthic zone, 114
Benthos, 105
Biodiversity conservation, 185
Biodiversity, 181
Biofertilizers, 269, 274
Biogas, 251
Biogeochemical cycles, 52, 54
Biological oxygen demand, 214
Biological system, 23
Biomes, 127
Biopiracy, 288, 300
Bioremediation, 260
Biosphere reserves, 194
Biosphere, 13, 28, 58
Biotic components, 7, 33
Blue-green algae, 271
Brackish water habitat, 31

C

Carbon cycle, 56
Carbonation, 24
Cardiac diseases, 201
Carnivores, 34
Carrying capacity, 76
Causes of succession, 92
Chemical weathering, 24
Chlorosis, 200
Climax community, 100
Commensalism, 9
Community ecology, 3
Components of soil, 22
Condensation, 15
Conservation projects, 191
Control of ecological succession, 96
Conventional energy resources, 243
Copyrights, 296
Crocodile project, 193

D

Deforestation, 236
Dendrothermal energy, 251
Density dependent factors, 80
Density independent factors, 7
Desert biomes, 132
Designs, 295
Detritus food chain, 35
Diarrhoea, 213
Diel periodicity, 98

E

Eastern ghats, 83, 86
Ecological diseases, 2
Ecological divisions of India, 81
Ecological energetics, 42
Ecological pyramid, 38
Ecological succession, 89
Ecosystem, 28
Eco-terrorism, 303
Elephant project, 193
Endangered species, 189, 254
Energy flow in the ecosystem, 43
Energy resources, 242
Environmental biotechnology, 259
Environmental degradation, 155
Environmental science, 1
Estuarine habitat, 120
Estuary, 120
Evolutionary ecology, 3
Exosphere, 11
Ex-situ bioremediation, 262
Ex-situ conservation, 231

F

Fertility, 26
Food chains, 34
Food webs, 36
Forest biomes, 128
Forest fires, 240
Freshwater habitats, 1, 102, 103

G

Genetic diversity, 77
Geographical barriers, 127
Geographical indications, 296
Geothermal energy, 250
Gir National Park, 138
Glaciation, 23
Global distribution of water, 12
Global warming, 163, 203
Grazing food chain, 35
Green house effect, 163, 206
Gross land biomes, 131

H

Habitat ecology, 3
Heat capacity, 16
Heavy metal pollution, 161
Herbivores, 7
Heterosphere, 11
Heterotrophs, 33
Host-parasite relationship, 9
Humus, 22
Hydrogen cycle, 67
Hydrological cycle, 14
Hydropower, 245
Hydrosphere, 6,12

I

Igneous rocks, 20
Indicators, 99
Indo-Gangetic plains, 84
Industrial effluents, 211
Industrial wastes, 213
In-situ bioremediation, 261
In-situ conservation, 231
Intellectual property rights, 292, 294
Inter-specific relationship, 9
Intra-specific relationship, 8
Ion-exchange capacity, 26
Ionizing radiations, 170

L

Latent heat, 16
Lentic habitat, 31, 105
Limnetic zone, 32
Lithosphere, 6, 19
Littoral zone, 32

Lotic habitat, 31, 107
Lunar periodicity, 98

M

Macro-consumers, 33
Major zones of atmosphere, 9
Mangroves, 134
Marine communities, 115
Marine habitat, 31, 115
Mesosphere, 11
Metamorphic rocks, 20, 21
Micro-consumers, 33
Minamata disease, 213
Moisture, 13
Mortality, 72

N

Nagzira National Park, 147
Natality, 71
National parks, 136
Natural ecosystem, 30
Natural gas, 244
Natural resources, 228
Neusten, 105
Nitrogen cycle, 54
Noise pollution, 217
Non- renewable energy resources, 242
Non-conventional energy resources, 246
Non-ionizing radiations, 174
Nuclear power, 245

O

Oxygen cycle, 60
Ozone depletion, 203
Ozone layer, 204

P

Pedoecology, 4
Patents, 294, 302
Pedogenesis, 25
Pelagic zone, 114
Periodicity, 97
Pesticides pollution, 220
Phosphorus cycle, 61
Physical weathering, 23
Physico-chemical characteristics of water, 16
Pneumonia, 201
Pollutants, 197
Pollution, 155, 197
Pond ecosystem, 31
Population density, 70
Population ecology, 69
Population genetics, 77
Population growth, 74
Population size, 74
Precipitation, 16
Prey-predator relationship, 9
Primary producers, 7
Primary succession, 94
Profundal zone, 32
Protected areas network, 191
Pyramid of biomass, 41
Pyramid of energy, 41
Pyramid of numbers, 39

R

Radiation ecology, 4, 170
Radioactive contamination, 176
Radioactive decays, 175
Realms, 127
Renewable energy resources, 242
Rock cycle, 21

S

Salinity, 18
Sanctuaries, 136
Seasonal periodicity, 98
Secondary succession, 94
Sedimentary rocks, 20

Single channel energy flow model, 44
Solar energy, 247
Solid waste pollution, 223
Space ecology, 4
Stratification, 114
Stratosphere, 10
Sub-littoral zone, 32
Sulphur cycle, 64
Sundarban National Park, 141
Sustainable development, 229
Symbiosis, 9
Synecology, 3
System ecology, 4

T

Terminator seed technology, 284
Terrestrial ecosystem, 30
Terrestrial habitats, 125
Terrorism, 308
Thermal conductivity, 17
Thermal pollution, 159
Thermal power, 244
Threatened species, 255
Tidal energy, 249
Tiger project, 192
Total alkalinity, 18
Trademarks, 295
Troposphere, 9
Tundra biomes, 127
Types of ecological succession, 93
Types of ecosystem, 30
Types of estuaries, 121
Types of rocks, 20

U

Universal model of energy flow, 48
Urbanization, 178
Vermi-composting, 279
Vermiculture, 275
Vulnerable species, 254

W

War on terrorism, 308
Water cycle, 65
Water pollution, 209
Water resources, 232
Weathering of soil forming rocks, 23
Western ghats, 84, 87
Wetland biomes, 133
Wildlife conservation, 253
Wind energy, 248
Wind velocity, 239

Y

Y-shaped energy flow model, 46

Z

Zonation in a pond, 32
Zonation of oceans, 114